Design of Beams using First Principles. & Drawing Reinforcement in Cross section.

نسألكم الدعاء

Design of Beams using First Principles. Table of Contents.

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Basic Considerations in L.S.D.M.

Design of Beams using Limits states Design Method.

* F.O.S. For Loads.

F.O.S. For Dead Load. = 1.4
F.O.S. For Live Load. = 1.6
} To increase the Load.

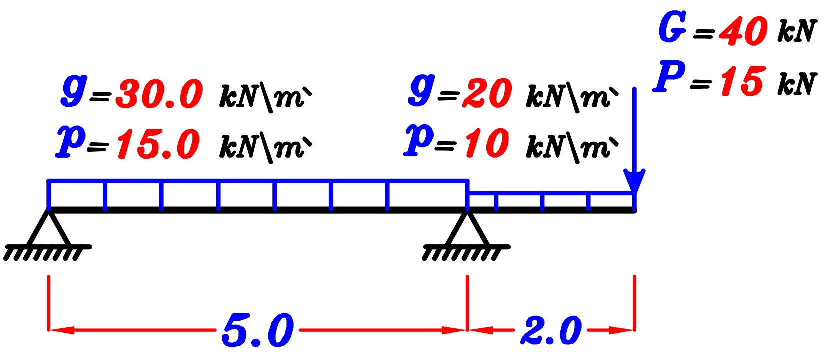
F.O.S. For Dead Load. = 0.9
F.O.S. For Live Load. = zero
} To decrease the Load.

Load (To Increase) = 1.4 D.L. + 1.6 L.L.

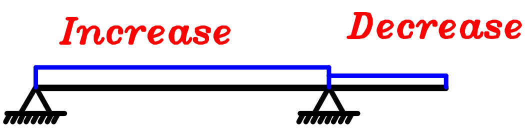
= 1.5 (D.L.+ L.L.) IF L.L. $\ngtr$ 0.75 D.L.

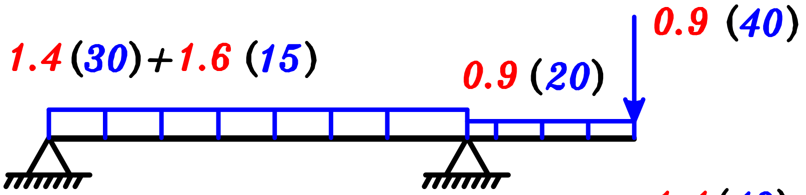
Load (To Decrease) = 0.9 D.L. + 0.0 L.L.

Example.

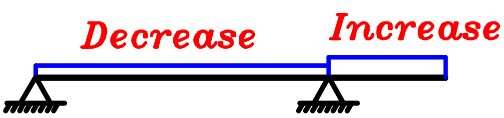


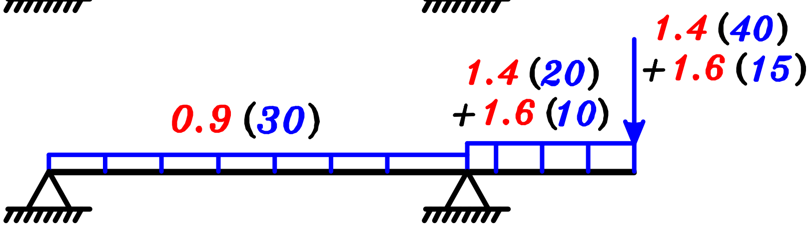
max. + Ve





max. – Ve





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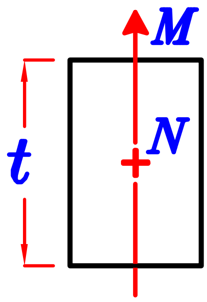
* F.O.S. For Materials.

1- Case of Axial and eccentric load. (M , N)

$$e = \frac{M}{N}$$



$$\gamma_c \text{ (Concrete)} = 1.5 \left[\left(\frac{7}{6}\right) - \frac{(e \backslash t)}{3} \right] \geq 1.5$$

$$\gamma_s \text{ (Steel)} = 1.15 \left[\left(\frac{7}{6}\right) - \frac{(e \backslash t)}{3} \right] \geq 1.15$$

2- Case of Flexure only. (M) only

$$\gamma_c = 1.5 \quad , \quad \gamma_s = 1.15$$

$\therefore$ Allowable stress For concrete. $= \dfrac{F_{cu}}{\gamma_c}$

Allowable stress For steel. $= \dfrac{F_y}{\gamma_s}$

We have three types of Sections.

1- Balanced Section. $\quad C = C_b = \dfrac{6000}{6000 + (F_y \backslash \gamma_s)} * d$

(Brittle Failure)

2- Under Reinforced Section. $\quad C < C_b$

(Ductile Failure)

3- Over Reinforced Section. $\quad C > C_b$

(Brittle Failure)

ملحوظة هامه

دائماً فى التصميم بطريقة ال U.L.D.M. يجب أن يكون القطاع

Under Reinforced Section.

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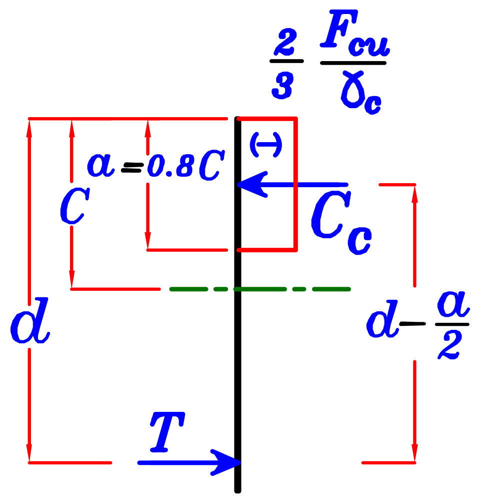
Properties of Under Reinforced Section.

① $C \leqslant C_{max.}$



where: $\boxed{C_{max} = \frac{2}{3} C_b}$

$$\therefore \boxed{C_{max} = \frac{2}{3}\left[\frac{600}{600+(F_y \backslash \gamma_s)} * d\right]}$$

---

② $a \leqslant a_{max.}$ $\boxed{a_{max.} = 0.8\ C_{max.}}$

$$\therefore \boxed{a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600+(F_y \backslash \gamma_s)} * d\right]}$$

---

③ $a \geqslant a_{min}$ $\boxed{a_{min} = 0.1\ d}$

IF $a < 0.1\ d \xrightarrow{Take} a = 0.1\ d$

---

④ $A_s \leqslant A_{s_{max.}}$

Where: $\boxed{\mu = \frac{A_s}{bd} = \frac{\text{مساحه الحديد الرئيسى}}{\text{مساحه الخرسانه}}}$

$\mu_{max.} = \frac{A_{s_{max.}}}{bd} \longrightarrow$ Code Page (4–7) Table (1–4)

$$\boxed{A_{s_{max.}} = \mu_{max.}\, b\ d}$$

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⑤ $A_s \geqslant A_{s\,min.}$ where $= \mu_{min.} = \dfrac{1.1}{F_y}$

$$A_{s\,min.}\ \text{(For Beams)} = \left.\begin{array}{l} \dfrac{1.1}{F_y}\, b\, d \\ 1.3\, A_{s\,req.} \end{array}\right\}\text{الأقل}\ \ \left.\begin{array}{l} \\ \\ \text{st. } 360/520 \quad \dfrac{0.15}{100}\, b\, d \\ \text{st. } 240/350 \quad \dfrac{0.25}{100}\, b\, d \end{array}\right\}\text{الأكبر}$$

Example.

From design of a given Sec. (250*700)

Found that $A_{s\,required} = 300\ mm^2$

to Check $A_{s\,min.}$ Calculate $\dfrac{1.1}{F_y}\, b\, d$

$$\frac{1.1}{F_y}\, b\, d = \frac{1.1}{360} * 250 * 650 = 496.5\ mm^2 > A_{s\,req.}$$

$$\therefore A_s < A_{s\,min.} \qquad \therefore \text{Take } A_s = A_{s\,min.}$$

$$A_{s\,min.} = \left.\begin{array}{l} \dfrac{1.1}{F_y}\, b\, d = \dfrac{1.1}{360} * 250 * 650 = 496.5 \\ 1.3\, A_{s\,req.} = 1.3 * 300 = 390 \end{array}\right\}\text{الأقل} = 390$$

$$\left.\begin{array}{l} 390 \\ \text{st. } 360/520 \quad \dfrac{0.15}{100}\, b\, d = \dfrac{0.15}{100} * 250 * 650 = 243.7 \end{array}\right\}\text{الأكبر} = 390\ mm^2$$

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⑥ $A_{s`} \leq A_{s`max.}$ IF we are using $A_{s`}$

where $\boxed{A_{s`max.} = 0.4 A_s}$

---

⑦ $d \geq d_{min.}$

Under Reinforced Section هو أقل عمق للقطاع يكون فية القطاع $d_{min.}$

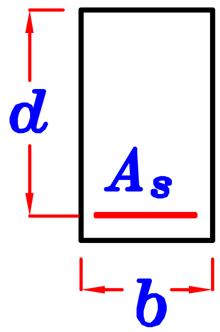
Over Reinforced Section و إذا قلت قيمة الـ d عن الـ $d_{min.}$ يصبح القطاع

IF $M_{U.L.}$ is given , We can get $d_{min.}$ by using

without $A_{s`}$

$$M_{U.L.} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} a_{max} \, b \left(d_{min.} - \frac{a_{max}}{2}\right)$$

$$\text{OR} \quad M_{U.L.} = R_{max.} \frac{F_{cu}}{\gamma_c} b \, d^2_{min.}$$

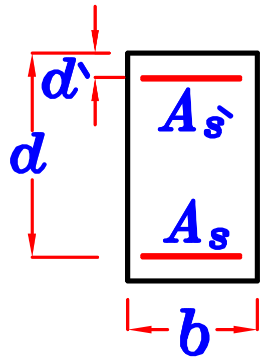


Code Page (4–7) Table (1–4)

IF $M_{U.L.}$ is given , by using $A_{s`}$

$$M_{U.L.} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} a_{max} \, b \left(d_{min} - \frac{a_{max}}{2}\right) + A_{s`} \frac{F_y}{\gamma_s} (d_{min} - d`)$$

$$\text{OR} \quad M_{U.L.} = R_{max.} \frac{F_{cu}}{\gamma_c} b \, d^2_{min.} + A_{s`} \frac{F_y}{\gamma_s} (d_{min} - d`)$$



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⑧ $M_{U.L.} \leqslant M_{U.L.\,max}$

اذا كان معطى عمق القطاع $d = \checkmark$ يجب أن لا يزيدالعزم المؤثر عن $M_{U.L._{max}}$

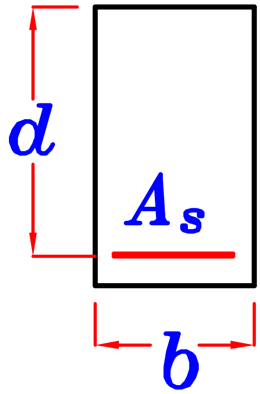
اذا زادت قيمة العزم المؤثر عن $M_{U.L._{max}}$ يصبح القطاع Over Reinforced Section

IF d is given , We can get $M_{U.L._{max}}$ by using

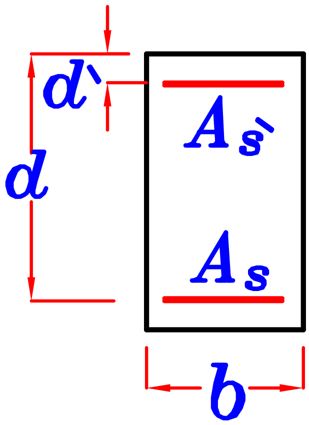
without $A_{s`}$

$$M_{U.L._{max}} = \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\,a_{max}\,b\left(d - \frac{a_{max}}{2}\right)$$

$$\text{OR}\quad M_{U.L._{max}} = R_{max.}\,\frac{F_{cu}}{\gamma_c}\,b\,d^2$$



with $A_{s`}$



$$M_{U.L._{max}} = \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\,a_{max}\,b\left(d - \frac{a_{max}}{2}\right) + A_{s`}\,\frac{F_y}{\gamma_s}\,(d - d`)$$

$$\text{OR}\quad M_{U.L._{max}} = R_{max.}\,\frac{F_{cu}}{\gamma_c}\,b\,d^2 + A_{s`}\,\frac{F_y}{\gamma_s}\,(d - d`)$$

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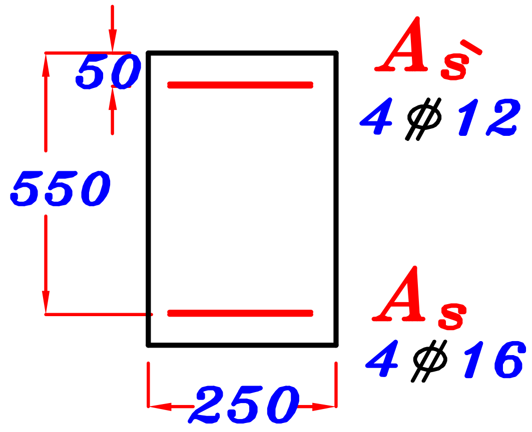
Example.

$F_{cu} = 25\ N/mm^2$ $\quad$ st. 360/520



Get $M_{U.L._{max}}$

$$A_s = 4\phi 16 = 804\ mm^2$$

$$A_{s`} = 4\phi 12 = 452\ mm^2$$

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \gamma_s)} * d\right]$$

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + \left(\frac{360}{1.15}\right)} * 550\right] = 192.7 mm$$

$$M_{U.L._{max}} = \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\,a_{max}\,b\left(d - \frac{a_{max}}{2}\right) + A_{s`}\,\frac{F_y}{\gamma_s}\,(d - d`)$$

$$\therefore M_{U.L._{max}} = \frac{2}{3}\left(\frac{25}{1.5}\right)(192.7)(250)\left(550 - \frac{192.7}{2}\right) + 452\left(\frac{360}{1.15}\right)(550 - 50)$$

$$= 313576590\ N.mm = 313.576\ kN.m$$

OR Get $R_{max.} = 0.194$ Code Page (4–7) Table (1–4)

$$M_{U.L._{max}} = R_{max.}\,\frac{F_{cu}}{\gamma_c}\,b\,d^2 + A_{s`}\,\frac{F_y}{\gamma_s}\,(d - d`)$$

$$M_{U.L._{max}} = 0.194\left(\frac{25}{1.5}\right)(250)(550)^2 + 452\left(\frac{360}{1.15}\right)(550 - 50)$$

$$= 315268659\ N.mm = 315.268\ kN.m$$

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يوجد فى الكود المصرى جدول يعطى قيم لمعلملات R_{max} & μ_{max} , $\frac{C_{max}}{d}$

Code Page (4–7) Table (1–4)

رتبه الحديد	$\frac{C_{max}}{d}$	μ_{max}	R_{max}
st. 240/350	0.50	$8.56 \times 10^{-4} \times F_{cu}$	0.214
st. 280/450	0.48	$7.0 \times 10^{-4} \times F_{cu}$	0.208
st. 360/520	0.44	$5.0 \times 10^{-4} \times F_{cu}$	0.194
st. 400/600	0.42	$4.31 \times 10^{-4} \times F_{cu}$	0.187
st. 450/520	0.40	$3.65 \times 10^{-4} \times F_{cu}$	0.180

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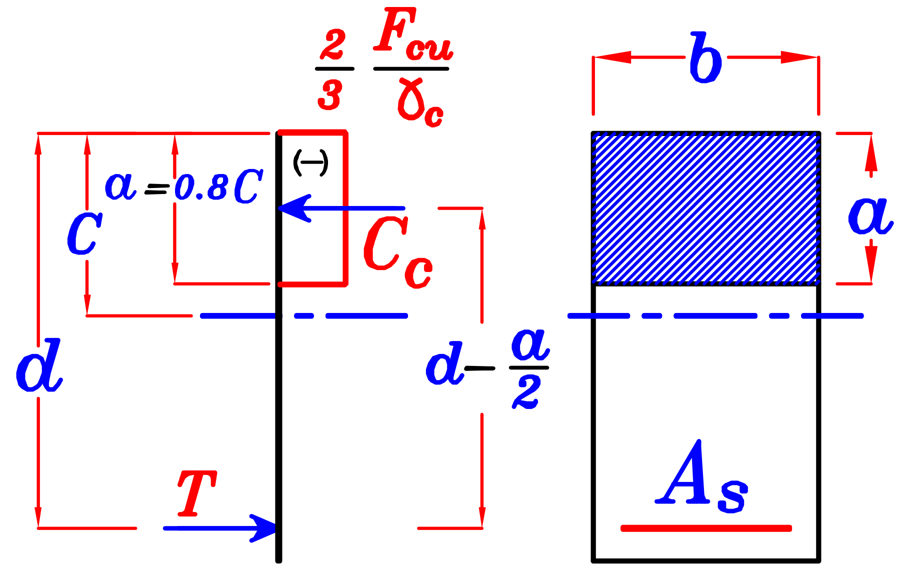
Design of R-Section Subjected to B.M. only Using First Principles.



نبدأ دائما بهذه المعادله لتحديد قيمه d أو a

$M = C *$ المسافه حتى الحديد

$$\boxed{M_{U.L.} = \frac{2}{3}\,\frac{F_{cu}}{\delta_c}\,a\,b\left(d-\frac{a}{2}\right)} \quad a\,,d$$

نعوض فى هذه المعادله اذا كان $a \geq 0.1\,d$ و ذلك لتحديد قيمه A_s

$C = T$

$$\boxed{\frac{2}{3}\,\frac{F_{cu}}{\delta_c} * a * b = A_s * \frac{F_y}{\delta_s}} \quad a\,,\ A_s$$

نعوض فى هذه المعادله اذا كان $a < 0.1d$ و ذلك لتحديد قيمه A_s

مع أخذ قيمه $a = 0.1d$

$M = T *$ المسافه حتى الخرسانه

$$\boxed{M_{U.L.} = A_s\,\frac{F_y}{\delta_s}\,\left(d-\frac{a}{2}\right)} \quad a\,,d\,,A_s$$

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Types of Problems.

Type ①

Given: F_{cu} , st. , b , $M_{U.L.}$

Req: d , A_s

Solution:

- $a_{min} = 0.1\,d$
- $a_{max} = 0.8\left(\frac{2}{3}\right)C_b = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600+(F_y \backslash \delta_s)}\right] * d$
- Choose a value between a_{min} , a_{max} $\boxed{a = \checkmark * d}$
- From $M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\delta_c}\, a\, b\left(d - \frac{a}{2}\right)$

$$M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\delta_c}(\checkmark\, d)\, b\left(d - \frac{(\checkmark\, d)}{2}\right) \xrightarrow{get} d$$

تقرب d لأقرب ٥٠ مم بالزياده

- $\boxed{t = d + 50\,mm = \checkmark}$

قبل التقريب

- Get $a = (\checkmark\, d)$
- Get A_s From $\frac{2}{3}\frac{F_{cu}}{\delta_c} * a * b = A_s * \frac{F_y}{\delta_s}$
- Check $A_{s\,min}$

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Example.

$F_{cu} = 25 \ N\backslash mm^2$ $\quad$ st. 360/520

$b = 0.25 \ m$ $\quad$ $M_{U.L.} = 150 \ kN.m$

Req: Get d , A_s

Solution.

– $a_{min} = 0.1 \ d$

– $a_{max} = 0.8\left(\frac{2}{3}\right) C_b = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y\backslash \gamma_s)}\right] * d$

$$= 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (360\backslash 1.15)}\right] * d = 0.35 \ d$$

– Choose a value between a_{min} , a_{max} $\quad \therefore$ Take $\boxed{a = (0.25\,d)}$

– From $M_{U.L.} = \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\, a\, b\left(d - \frac{a}{2}\right)$

$$150 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(0.25\,d)(250)\left(d - \frac{0.25\,d}{2}\right)$$

$\therefore d = 496.8 \ mm$ $\quad \therefore \boxed{d = 500 \ mm}$

$$\boxed{t = 500 + 50 = 550 \ mm}$$

قبل التقريب

– Get $a = 0.25 \ d = 0.25 * 496.8 = 124.2 \ mm$

– Get A_s From $\frac{2}{3}\,\frac{F_{cu}}{\gamma_c} * a * b = A_s * \frac{F_y}{\gamma_s}$

$$\frac{2}{3}\left(\frac{25}{1.5}\right)(124.2)(250) = A_s\left(\frac{360}{1.15}\right)$$

$$\therefore \boxed{A_s = 1102.0 \ mm^2}$$

بعد التقريب

– Check $A_{s_{min.}} = \frac{1.1}{F_y}\, b\, d = \frac{1.1}{360}(250)(500) = 381.9 \ mm^2$

$$\therefore A_{s_{min.}} < A_s = 1102.0 \ mm^2$$

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Type ②

Given: F_{cu} , st. , b , d , $M_{U.L.}$

Req: A_s , $A_{s'}$ IF Required.

Solution.

Calculate $a_{max} = 0.8\ C_{max} = 0.8\left(\frac{2}{3}\right) C_b = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \gamma_s)}\right] * d$

Calculate $M_{U.L._{max.}} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, a_{max.}\, b\left(d - \frac{a_{max.}}{2}\right)$

* IF $M_{U.L.} \leqslant M_{U.L._{max.}} \longrightarrow$ No need to use Compressive steel $(A_{s'})$

– Get a From

$$M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, a\, b\left(d - \frac{a}{2}\right)$$

$$\boxed{a}$$

IF $a \leqslant 0.1\, d$

Take $a = 0.1\, d$

– Get A_s From

$$M_{U.L.} = A_s \frac{F_y}{\gamma_s}\left(d - \frac{a}{2}\right)$$

$$M_{U.L.} = A_s \frac{F_y}{\gamma_s}\left(d - \frac{0.1\, d}{2}\right)$$

– Check $A_{s_{min.}}$

IF $a > 0.1\, d$

– Get A_s From

$$\frac{2}{3}\frac{F_{cu}}{\gamma_c} * a * b = A_s * \frac{F_y}{\gamma_s}$$

Check $A_{s_{min.}}$

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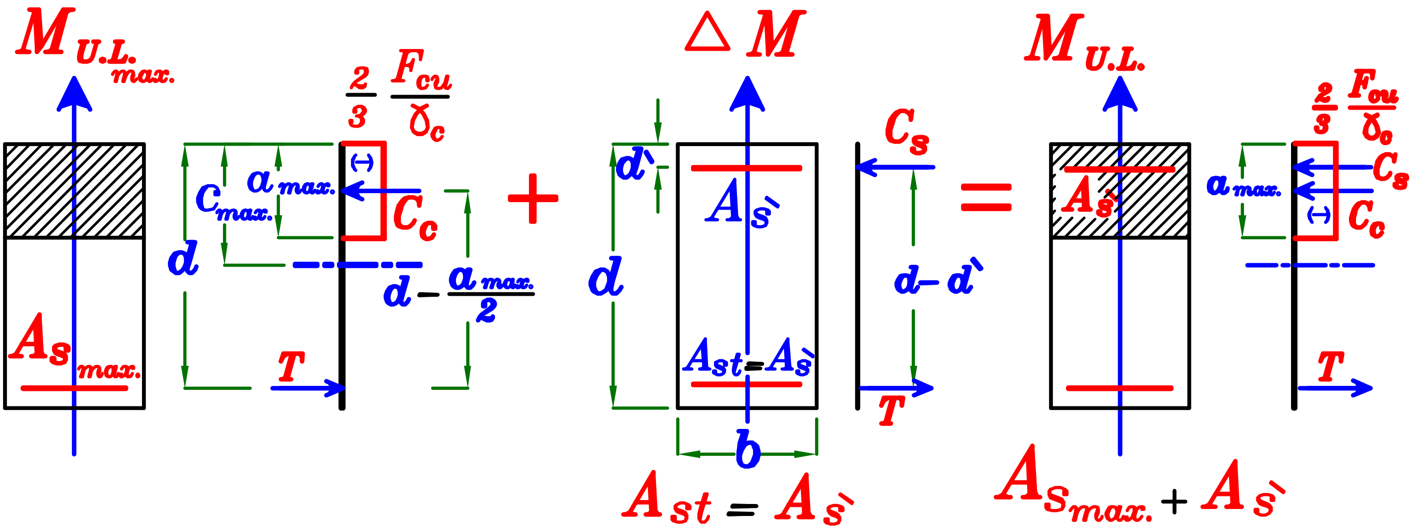
$* \; IF \; M_{U.L.} > M_{U.L._{max.}}$

$\therefore$ We need to use Compressive steel $(A_{s`})$

$\therefore$ We have to put a Compressive Steel to be able to increase Tension Steel $A_s > A_{s_{max.}}$ and the Sec. still Under Reinforced Sec.



$$M_{U.L._{max.}} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} a_{max.} b \left(d - \frac{a_{max.}}{2}\right)$$

$$\triangle M = M_{U.L.} - M_{U.L._{max.}} = C_s \; (d-d`) \; = \; A_{s`} \frac{F_y}{\gamma_s} (d-d`)$$

Conditions to use $A_{s`}$

1- $A_{s`_{max.}} = \dfrac{40}{100} A_s$

2- $\dfrac{d`}{d} \leqslant 0.20 \qquad$ st. 240/350

$\leqslant 0.15 \qquad$ st. 360/520

$\leqslant 0.10 \qquad$ st. 400/600

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* IF $M_{U.L.} > M_{U.L._{max.}}$

$\therefore$ We need to use Compressive steel ($A_{s`}$)

- Get $\triangle M = M_{U.L.} - M_{U.L._{max.}}$

- Get $A_{s`}$ From $\triangle M = A_{s`} \frac{F_y}{\gamma_s} (d - d`)$

$$\therefore \boxed{A_s = A_{s_{max.}} + A_{s`} = \mu_{max.}\, b\, d + A_{s`}}$$

- Check $A_{s`_{max.}} = 0.4\ A_s$

① IF $A_{s`} \leq A_{s`_{max.}} \longrightarrow$ o.k.

② IF $A_{s`} > A_{s`_{max.}} \longrightarrow$ we have to increase dimensions.

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Type ②

Given: F_{cu} , st. , b , d , $M_{U.L.}$

Req: A_s , $A_s^{`}$ IF Required

Calculate $a_{max} = 0.8\, C_{max} = 0.8\left(\frac{2}{3}\right) C_b = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \gamma_s)}\right] * d$

Calculate $M_{U.L._{max}} = \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\, a_{max}\, b\left(d - \frac{a_{max}}{2}\right)$

$\boxed{M_{U.L.}}$

$\boxed{IF\ M_{U.L.} \leqslant M_{U.L._{max.}}}$

(No need to use $A_s^{`}$)

- Get a From

$M_{U.L.} = \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\, a\, b\left(d - \frac{a}{2}\right)$

$\boxed{a}$

IF $a \leqslant 0.1\, d$

Take $a = 0.1\, d$

- Get A_s From

$M_{U.L.} = A_s \frac{F_y}{\gamma_s}\left(d - \frac{0.1\, d}{2}\right)$

IF $a > 0.1\, d$

- Get A_s From

$\frac{2}{3}\,\frac{F_{cu}}{\gamma_c} * a * b = A_s * \frac{F_y}{\gamma_s}$

Check $A_{s_{min.}}$

$A_{s_{min.}} = \left.\begin{matrix} \frac{1.1}{F_y}\, b\, d \\ 1.3\, A_{s\,req.} \end{matrix}\right\}$ الأقل

st. 360/520 $\quad \frac{0.15}{100}\, b\, d$

st. 240/350 $\quad \frac{0.25}{100}\, b\, d$

الأكبر (الأقل of the two values above, and the st. value below)

$\boxed{IF\ M_{U.L.} > M_{U.L._{max.}}}$

(We need to use $A_s^{`}$)

- Get $\triangle M = M_{U.L.} - M_{U.L._{max.}}$
- Get $A_s^{`}$ From

$\triangle M = A_s^{`} \frac{F_y}{\gamma_s}\left(d - d^{`}\right)$

- Get $\boxed{\begin{matrix} A_s = A_{s_{max.}} + A_s^{`} \\ A_s = \mu_{max.}\, b\, d + A_s^{`} \end{matrix}}$
- Check $A_{s^{`}_{max.}} = 0.4\, A_s$

IF $A_s^{`} < A_{s^{`}_{max.}}$

o.k.

IF $A_s^{`} > A_{s^{`}_{max.}}$

Increase Dimensions

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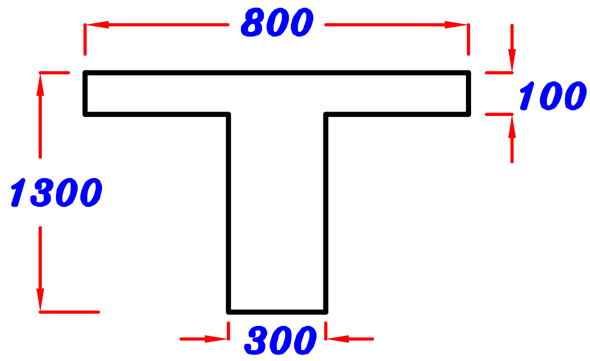
Example.

$F_{cu} = 25\ N\backslash mm^2$

st. 360/520

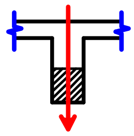


Req: Get A_s , A_s' IF Required $\quad M_{U.L.} = 400$ kN.m

and draw Details of RFT. in Cross sec.

Solution.

$d = 1200$ mm $\quad$ R–Sec.



$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y\backslash\delta_s)}\right] * d = 0.35\,d = 0.35 * 1200 = 420\ mm$$

$$M_{U.L._{max}} = \frac{2}{3}\frac{F_{cu}}{\delta_c}\,a_{max}\,b\left(d - \frac{a_{max}}{2}\right) = \frac{2}{3}\left(\frac{25}{1.5}\right)(420)(300)\left(1200 - \frac{420}{2}\right) = 1386000000\ N.mm$$

$$= 1386\ kN.m$$

$\because M_{U.L.} < M_{U.L._{max.}}$ $\quad \therefore$ No need to use A_s'

– Get a From $M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\delta_c}\,a\,b\left(d - \frac{a}{2}\right)$

$$\therefore 400 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(a)(300)\left(1200 - \frac{a}{2}\right) \longrightarrow \boxed{a = 104.55\ mm} < 0.1\,d$$

$\therefore$ Take $a = 0.1\,d$

– Get A_s From $\quad M_{U.L.} = A_s\frac{F_y}{\delta_s}\left(d - \frac{0.1\,d}{2}\right)$

$$400 * 10^6 = A_s\left(\frac{360}{1.15}\right)\left(1200 - \frac{120}{2}\right) \longrightarrow \boxed{A_s = 1121\ mm^2}$$

– Check $A_{s_{min.}}$

$$A_s = \frac{1.1}{F_y}\,b\,d = \frac{1.1}{360}(300)(1200) = 1100\ mm^2$$

$\therefore A_s > A_{s_{min.}}$ $\quad \therefore$ o.k.

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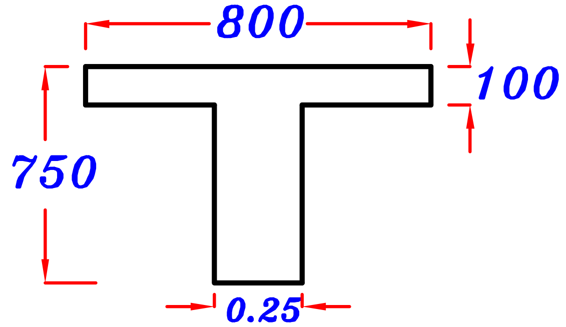
Example.

$F_{cu} = 25 \ N\backslash mm^2$ st. 360/520

$M_{U.L.} = 500 \ kN.m$

$b = 0.25 \ m$ $d = 0.70 \ m$

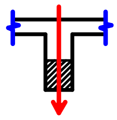


$M_{U.L.} = 500 \ kN.m$

Get A_s , $A_s`$ IF Required

Solution.

$d = 700 mm$ R-Sec.



$$a_{max} = 0.8 \left(\frac{2}{3}\right) \left[\frac{600}{600 + (F_y \backslash \gamma_s)}\right] * d = 0.35 d = 0.35 * 700 = 245 \ mm$$

$$M_{U.L._{max}} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} a_{max} \, b \left(d - \frac{a_{max}}{2}\right) = \frac{2}{3} \left(\frac{25}{1.5}\right)(245)(250)\left(700 - \frac{245}{2}\right) = 393020833 \ N.mm$$

$$= 393 \ kN.m$$

$\because M_{U.L.} > M_{U.L._{max.}}$ $\therefore$ We need to use $A_s`$

– Get $\Delta M = M_{U.L.} - M_{U.L._{max.}} = 500 - 393 = 107 \ kN.m$

– Get $A_s`$ From $\Delta M = A_s` \frac{F_y}{\gamma_s} (d - d`)$

$$\therefore 107 * 10^6 = A_s` \left(\frac{360}{1.15}\right)(700 - 50) \longrightarrow \boxed{A_s` = 525 \ mm^2}$$

From Code Page (4–7) Table (1–4)

$$\mu_{max.} = 5 * 10^{-4} F_{cu} = 5 * 10^{-4} * 25 = 0.0125$$

$$\therefore A_s = \mu_{max.} b d + A_s` = 0.0125 (250)(700) + 525 = 2712 \ mm^2$$

$$\therefore \boxed{A_s = 2712 mm^2}$$

– Check $A_{s`_{max.}} = 0.4 A_s = 0.4 (2712) = 1084.8 \ mm^2$

$\therefore A_s` < A_{s`_{max.}}$ $\therefore$ o.k.

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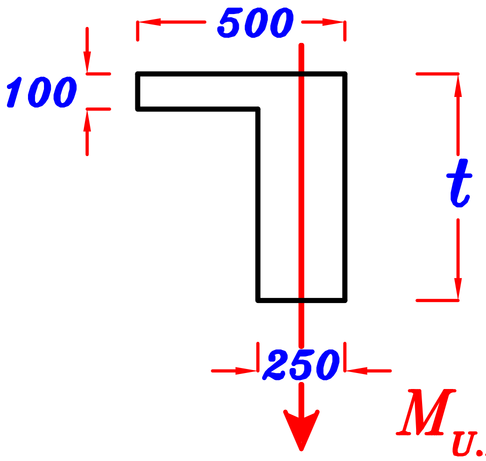
Example.

$F_{cu} = 25 \ N\backslash mm^2$

st. $360/520$

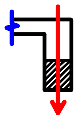


$M_{U.L.} = 350 \ kN.m$

Req.

Using First Principles Design the Sec. For Bending With min. Depth. & without A_{s}'

Solution.

R-Sec. 

To get $d_{min.}$ $\xrightarrow{use}$ $a = a_{max.}$, $A_s = A_{s_{max.}}$

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \gamma_s)}\right] * d = 0.35 \ d$$

$$\mu_{max.} = 5 * 10^{-4} * F_{cu} = 5 * 10^{-4} (25) = 0.0125$$

$$A_{s_{max.}} = \mu_{max.} \ b \ d = 0.0125 (250) \ d = 3.125 \ d$$

From $$M_{U.L._{max.}} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} a_{max.} b \left(d - \frac{a_{max.}}{2}\right)$$

$$\therefore 350 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(0.35 \ d)(250)\left(d - \frac{0.35 \ d}{2}\right)$$

$$\therefore d_{min.} = 660.57 \ mm \xrightarrow{Take} \boxed{d = 700 \ mm} \ , \ \boxed{t = 750 \ mm}$$

- Get A_s From

$$A_{s_{max.}} = 3.125 \ d = 3.125 \ (660.57) = 2064.28 \ mm^2$$

$$\boxed{A_s = A_{s_{max.}} = 2064.28 \ mm^2}$$

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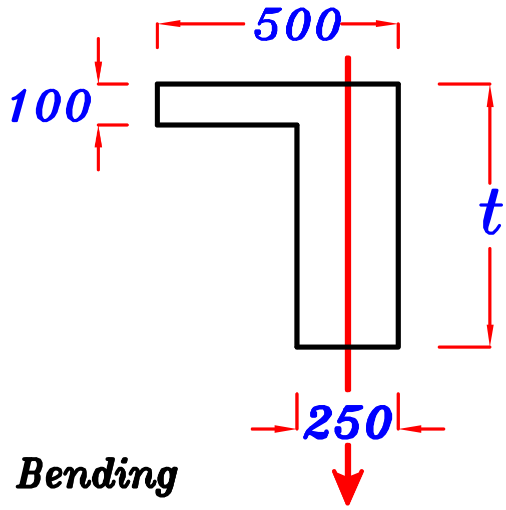
Example.

$F_{cu} = 25 \ N\backslash mm^2$

st. 360/520

Req.

Using First Principles Design the Sec. For Bending With min. Depth. & with $A_{s`}$



$M_{U.L.} = 350$ kN.m

Solution. To get $d_{min.}$

Take $a = a_{max.}$, $A_s = A_{s_{max.}} + A_{s`}$ , $A_{s`} = A_{s`_{max.}}$

$$A_{s`_{max.}} = 0.4 A_s = 0.4 \left( A_{s_{max.}} + A_{s`_{max.}} \right)$$

$$\therefore A_{s`_{max.}} = 0.4 \left( \mu_{max.} b \, d + A_{s`_{max.}} \right)$$

$$\therefore A_{s`_{max.}} = 0.4 \mu_{max.} b \, d + 0.4 A_{s`_{max.}}$$

$$\therefore 0.6 A_{s`_{max.}} = 0.4 \mu_{max.} b \, d$$

$$\therefore \boxed{A_{s`_{max.}} = \frac{2}{3} \mu_{max.} b \, d}$$

$$a_{max} = 0.8 \left(\frac{2}{3}\right) \left[\frac{600}{600 + (F_y \backslash \delta_s)} \right] * d = 0.35 \, d$$

$$\mu_{max.} = 5 * 10^{-4} * F_{cu} = 5 * 10^{-4} (25) = 0.0125$$

$$A_{s_{max.}} = \mu_{max.} b \, d = 0.0125 \, (250) \, d = 3.125 \, d$$

$$A_{s`_{max.}} = \frac{2}{3} \mu_{max.} b \, d = \frac{2}{3} (0.0125)(250) \, d = 2.08 \, d$$

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From $M_{U.L._{max.}} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, a_{max.}\, b\,(d - \frac{a_{max.}}{2}) + A_{s`_{max.}}\frac{F_y}{\gamma_s}(d - d`)$

$\therefore 350 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(0.35\,d)(250)\left(d - \frac{0.35\,d}{2}\right) + (2.08d)\left(\frac{360}{1.15}\right)(d - 50)$

$\therefore d = 502.09\ mm$ $\xrightarrow{Take}$ $\boxed{d = 550\ mm}$, $\boxed{t = 600\ mm}$

- Get A_s From

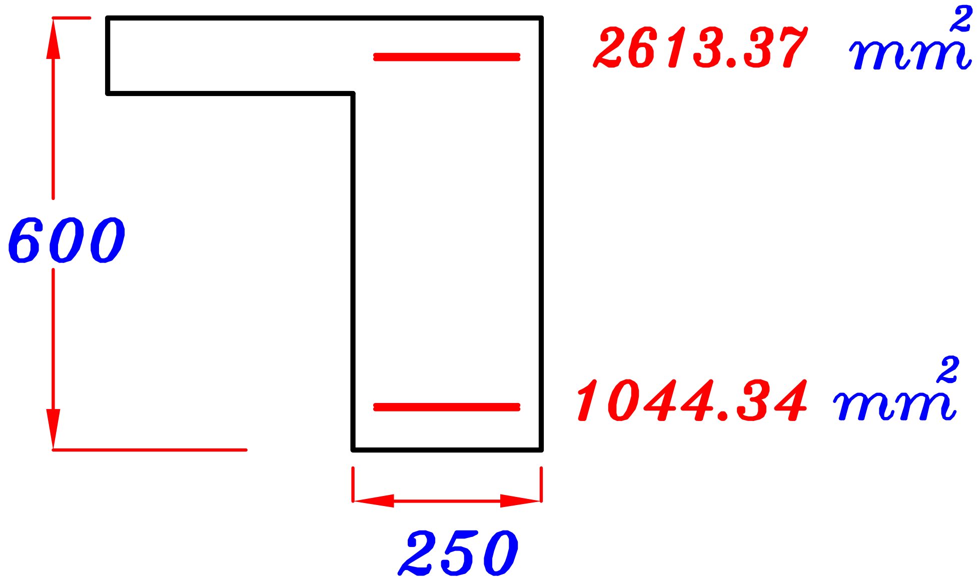
$$A_{s_{max.}} = 3.125\,d = 3.125\,(502.09) = 1569.03\ mm^2$$

$$A_{s`_{max.}} = 2.08\,d = 2.08\,(502.09) = 1044.34\ mm^2$$

$$\boxed{A_{s`} = A_{s`_{max.}} = 1044.34\ mm^2}$$

$$A_s = A_{s_{max.}} + A_{s`_{max.}} = 1569.03 + 1044.34 = 2613.37\ mm^2$$

$$\boxed{A_s = 2613.37\ mm^2}$$



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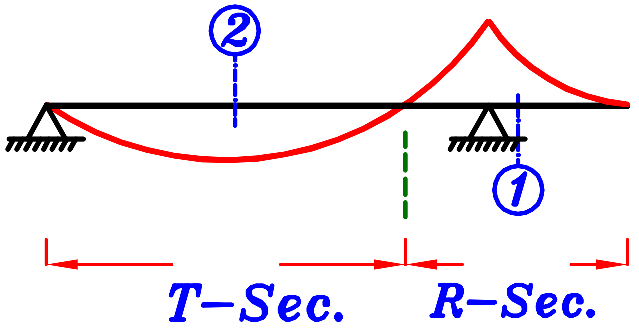
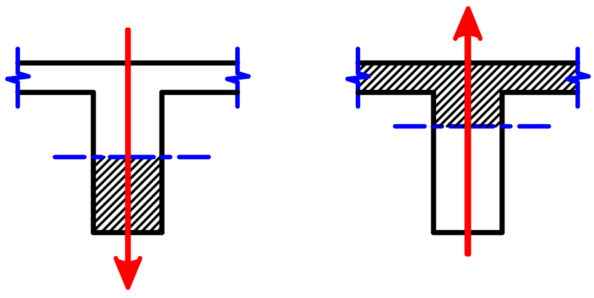
Design of T-Section & L-Section Using First Principles.

* T-Section. (أى أن البلاطة من الإتجاهين) كمره وسطيه



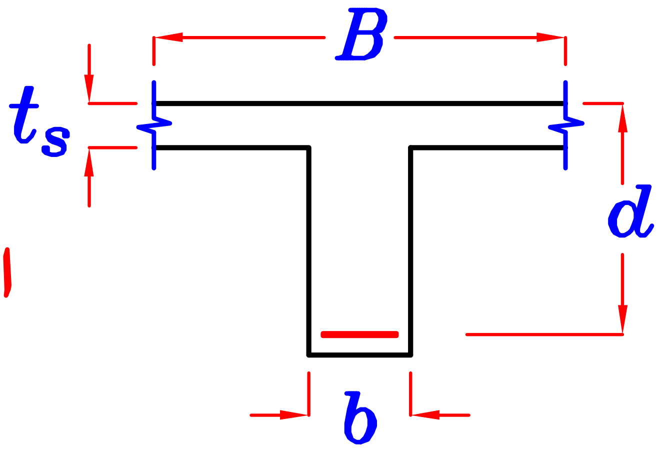


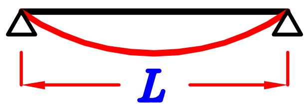
Sec. (1-1) R-section

Sec. (2-2) T-section

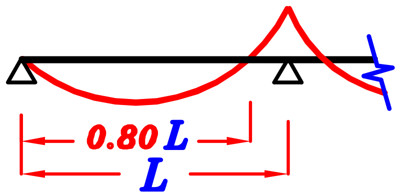
Effective Width. (B)

$$B = \left\{ \begin{array}{l} C.L._{slab} - C.L._{slab} \\ 16\,t_s + b \\ K\,\frac{L}{5} + b \end{array} \right\} \text{الأقل}$$

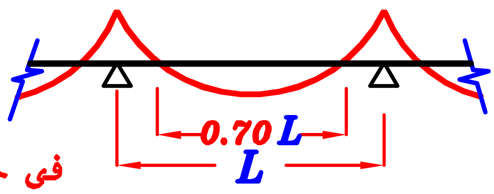




$K = 1.0$



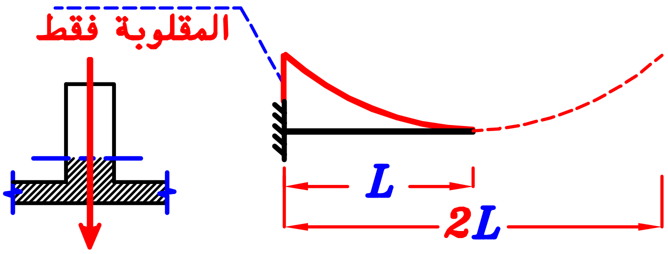
$K = 0.80$



$K = 0.70$

في حالة الكمرات

المقلوبة فقط



$K = 2.0$

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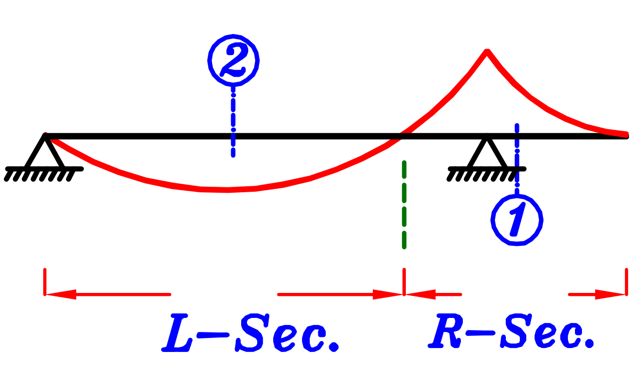
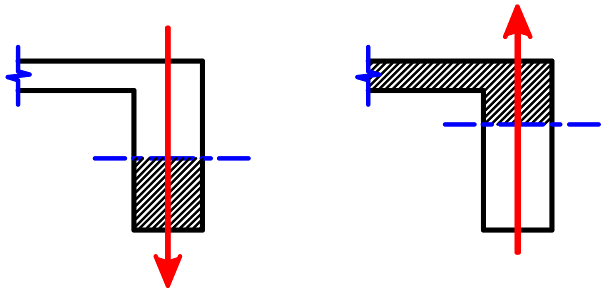
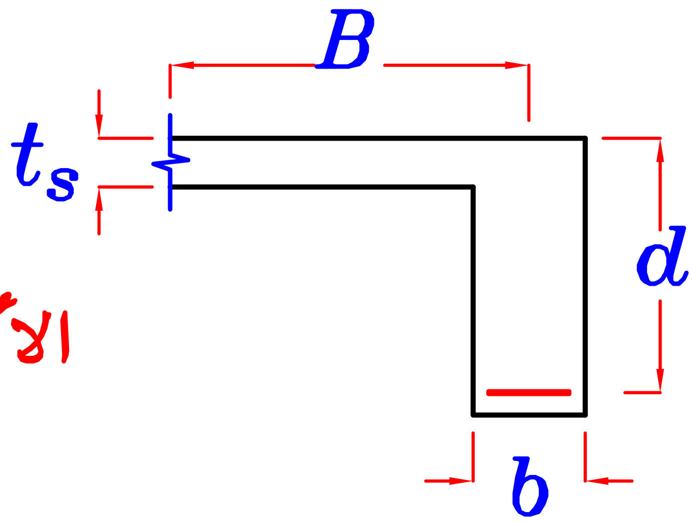
* L-Sections. (أى أن البلاطة من جهة واحده) كمره طرفية

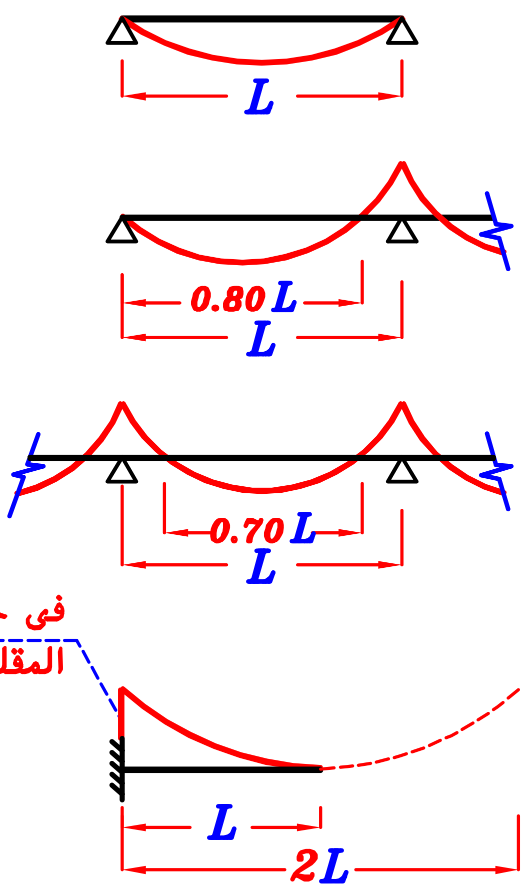




Effective Width. (B)

$$B = \begin{Bmatrix} C.L._{beam} - C.L._{slab} \\ 6\,t_s + b \\ K\,\dfrac{L}{10} + b \end{Bmatrix} \text{ الأقل}$$



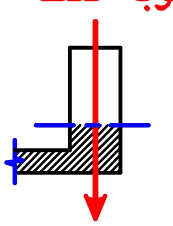


$K = 1.0$

$K = 0.80$

$K = 0.70$

فى حالة الكمرات المقلوبة فقط



$K = 2.0$

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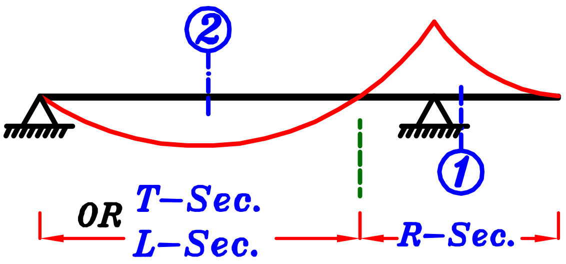
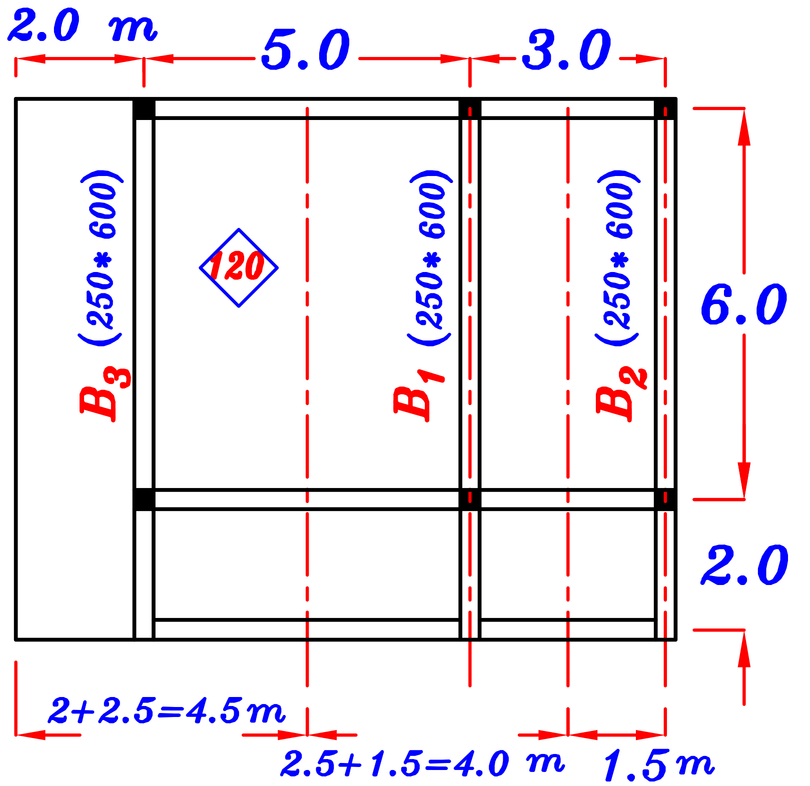
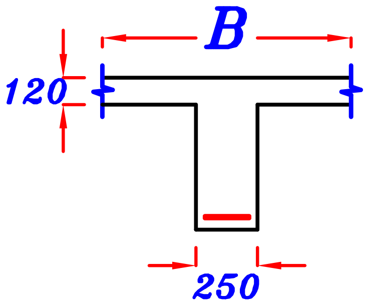
Example.

Get B For B_1 , B_2 , B_3



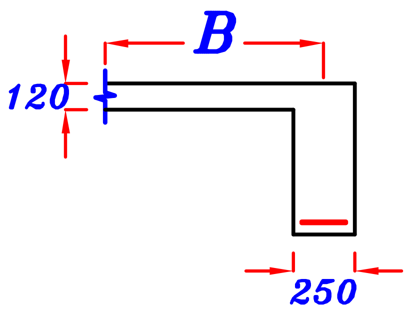


B_1 كمره وسطية



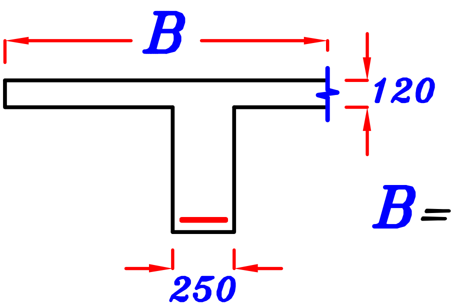
$$B = \begin{cases} C.L.-C.L. = 2.5+1.5 = 4.0\ m = 4000\ mm \\ 16\ t_s + b = 16 * 120 + 250 = 2170\ mm \\ K\ \frac{L}{5} + b = 0.8 * \frac{6000}{5} + 250 = 1210\ mm \end{cases} = 1210\ mm$$

B_2 كمره طرفية



$$B = \begin{cases} C.L.-C.L. = 1.5\ m = 1500\ mm \\ 6\ t_s + b = 6 * 120 + 250 = 970\ mm \\ K\ \frac{L}{10} + b = 0.8 * \frac{6000}{10} + 250 = 730\ mm \end{cases} = 730\ mm$$

B_3 كمره وسطية



$$B = \begin{cases} C.L.-C.L. = 2.5+2.0 = 4.5\ m = 4500\ mm \\ 16\ t_s + b = 16 * 120 + 250 = 2170\ mm \\ K\ \frac{L}{5} + b = 0.8 * \frac{6000}{5} + 250 = 1210\ mm \end{cases} = 1210\ mm$$

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Steps of Design.

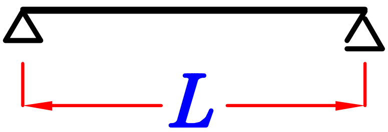
- IF d is not given, assume d

$$d = t - 50 \text{ mm} \qquad \text{IF} \quad t \leqslant 1000 \text{ mm}$$

$$d = t - 100 \text{ mm} \qquad \text{IF} \quad t > 1000 \text{ mm}$$

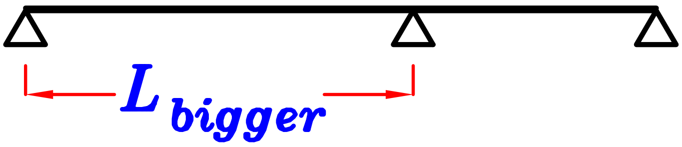
Choose t

Simple Beam



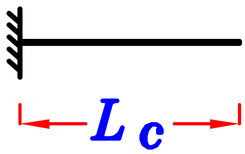
$$\boxed{t = \frac{L}{10}}$$

Continuos Beam



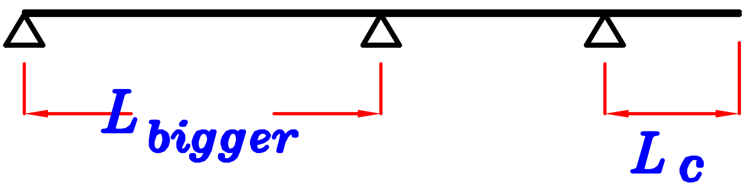
$$\boxed{t = \frac{L_{bigger}}{12}}$$

Cantilever Beam



$$\boxed{t = \frac{L_c}{5}}$$

Beam with Cantilever



$$\left.\begin{array}{c} \dfrac{L_{bigger}}{12} \\[2ex] \dfrac{L_c}{5} \end{array}\right\} \text{الاكبر}$$

$$\boxed{t_{min.} = 400 \text{ mm}}$$

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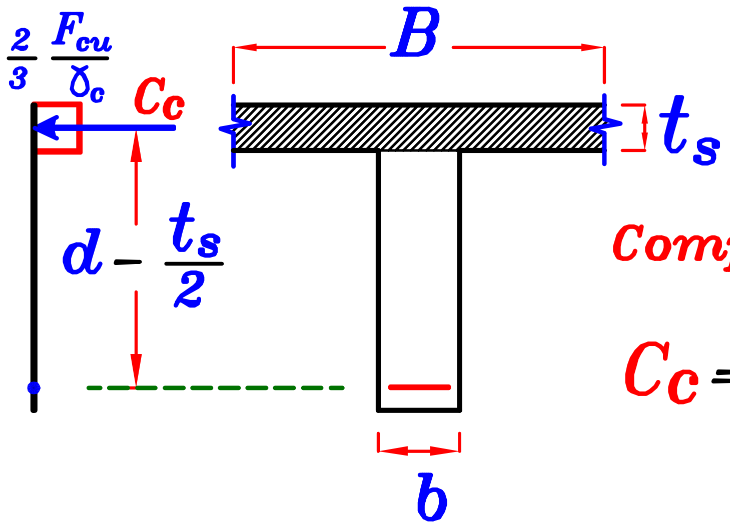
Calculate M_{Flange}



نفرض ان قيمه $a = t_s$

فتكون قيمه Compression Force

$$C_c = \frac{2}{3}\frac{F_{cu}}{\gamma_c} * (B * t_s)$$

نحسب العزم عند الحديد M_{Flange}

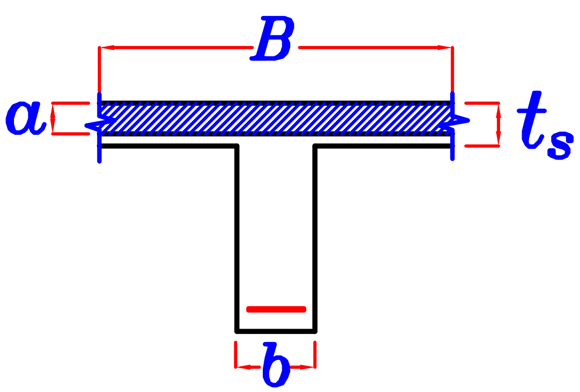
$$\boxed{M_{Flange} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, t_s\, B \left(d - \frac{t_s}{2}\right)}$$

$\boxed{M_{Flange}}$

IF $M_{U.L.} \leqslant M_{Flange}$

اذا سنحتاج لـ C_c اصغر من السابقه

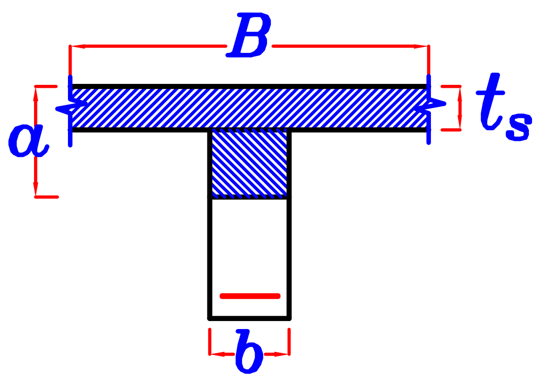
اذا $\boxed{a \leqslant t_s}$



IF $M_{U.L.} > M_{Flange}$

اذا سنحتاج لـ C_c اكبر من السابقه

اذا $\boxed{a > t_s}$



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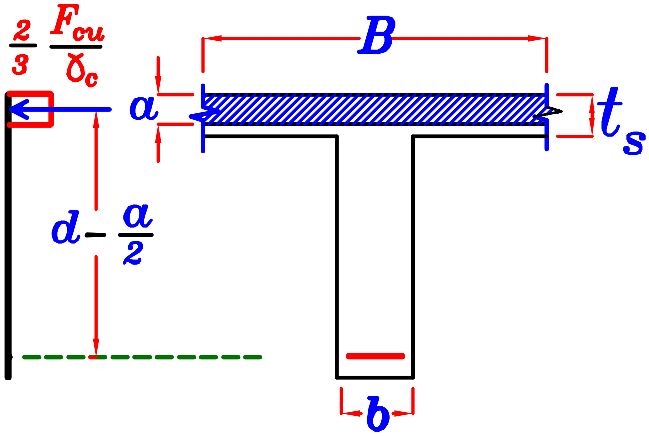
* IF $M_{U.L.} \leqslant M_{Flange}$

$\therefore a < t_s$



and the Sec. will acts as R–Sec. But with width B

– Get a From.

$$M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, a\, B\left(d-\frac{a}{2}\right) \xrightarrow{Get} a$$

Note that $a \leqslant t_s$

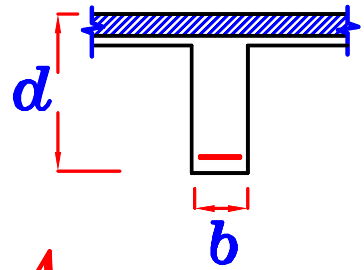
① IF $a > 0.1\, d$

– Get A_s From $\frac{2}{3}\frac{F_{cu}}{\gamma_c} * a * B = A_s * \frac{F_y}{\gamma_s}$

② IF $a < 0.1\, d \xrightarrow{Take} a = 0.1\, d$

– Get A_s From $M_{U.L.} = A_s \frac{F_y}{\gamma_s}\left(d-\frac{0.1\, d}{2}\right)$

– Check $A_{s_{min.}}$



الصغيره

IF $A_s \geqslant \frac{1.1}{F_y}\, b\, d$ $\therefore$ o.k.

IF $A_s < \frac{1.1}{F_y}\, b\, d \longrightarrow A_s < A_{s_{min.}} \xrightarrow{Take} A_s = A_{s_{min.}}$

$A_{s_{min.}}$ (For Beams) $=$ الأكبر {
- الأقل { $\frac{1.1}{F_y}\, b\, d$; $1.3\, A_{s\,req.}$ }
- st. 360/520: $\frac{0.15}{100}\, b\, d$
- st. 240/350: $\frac{0.25}{100}\, b\, d$
}

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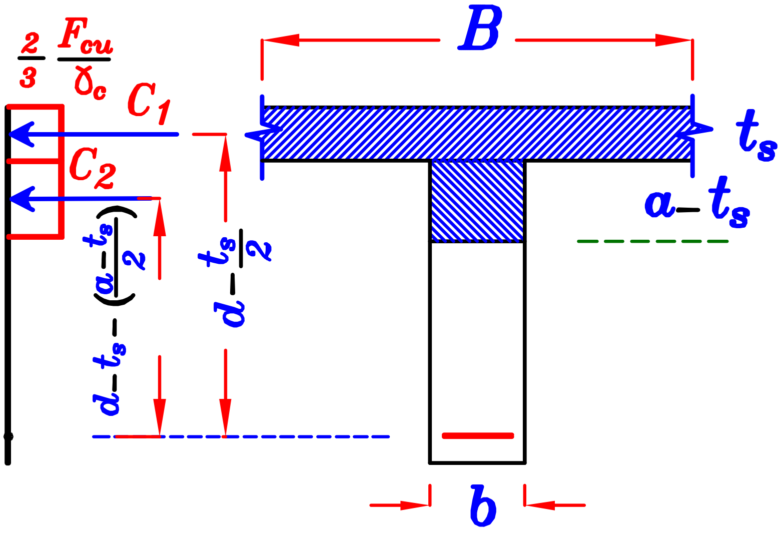
$* \; IF \; M_{U.L.} > M_{Flange}$ حالة نادرة

$\therefore \; a > t_s$



$$C_1 = \frac{2}{3}\frac{F_{cu}}{\delta_c} * t_s * B$$

$$C_2 = \frac{2}{3}\frac{F_{cu}}{\delta_c} (a - t_s) * b$$

Get a From taking the moment about Tension Steel.

$$M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\delta_c} t_s \, B \left(d - \frac{t_s}{2}\right) + \frac{2}{3}\frac{F_{cu}}{\delta_c} (a - t_s) \, b \left[d - t_s - \left(\frac{a - t_s}{2}\right)\right]$$

Note that $a > t_s$

– Get $a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \delta_s)}\right] * d$

① IF $a < a_{max.} \xrightarrow{Get} A_s$ From

$$\frac{2}{3}\frac{F_{cu}}{\delta_c} t_s \, B + \frac{2}{3}\frac{F_{cu}}{\delta_c} (a - t_s) \, b = A_s \frac{F_y}{\delta_s}$$

② IF $a > a_{max.}$

Note: Don't you ever use A_s` with T–sec. & L–sec.

$\therefore$ We have to increase $d \xrightarrow{Get} d_{new}$ From

Take $a = a_{max.} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \delta_s)}\right] * d_{new} = X \, d_{new}$

$$\because M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\delta_c} t_s \, B \left(d_{new} - \frac{t_s}{2}\right) + \frac{2}{3}\frac{F_{cu}}{\delta_c} (a_{max.} - t_s) \, b \left[d_{new} - t_s - \left(\frac{a_{max.} - t_s}{2}\right)\right]$$

$$\therefore M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\delta_c} t_s \, B \left(d_{new} - \frac{t_s}{2}\right) + \frac{2}{3}\frac{F_{cu}}{\delta_c} (X d_{new} - t_s) \, b \left[d_{new} - t_s - \left(\frac{X d_{new} - t_s}{2}\right)\right]$$

$\therefore$ Get $d_{new} \longrightarrow$ Get $a_{max.} = X \, d_{new}$

– Get A_s From

$$\frac{2}{3}\frac{F_{cu}}{\delta_c} t_s \, B + \frac{2}{3}\frac{F_{cu}}{\delta_c} (a_{max.} - t_s) \, b = A_s \frac{F_y}{\delta_s}$$

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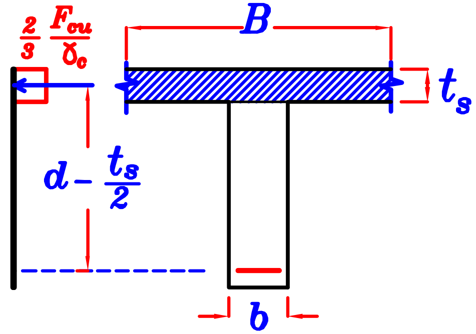
1 – IF d is given.

Design of T–sec. & L–sec. subjected to B.M. only

Get $M_{Flange} = \frac{2}{3} \frac{F_{cu}}{\delta_c} t_s B (d - \frac{t_s}{2})$

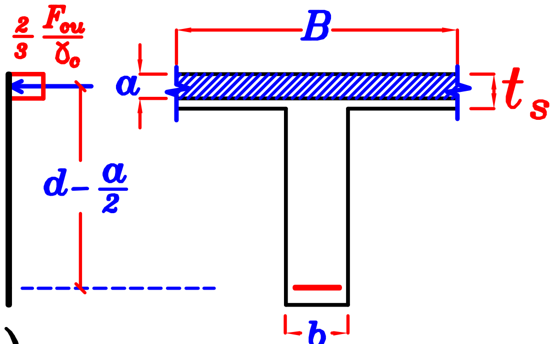


$\boxed{M_{Flange}}$

IF $M_{U.L.} \leqslant M_{Flange}$

$\therefore a < t_s$

$\therefore$ From



$$M_{U.L.} = \frac{2}{3} \frac{F_{cu}}{\delta_c} a B (d - \frac{a}{2})$$

Get $\boxed{a}$

IF $a < 0.1\, d$

$\therefore$ Take $a = 0.1\, d$

– Get A_s From

$$M_{U.L.} = A_s \frac{F_y}{\delta_s} (d - \frac{0.1\, d}{2})$$

IF $a > 0.1\, d$

Get A_s

From $\frac{2}{3} \frac{F_{cu}}{\delta_c} * a * B = A_s * \frac{F_y}{\delta_s}$

– Check $A_{s_{min.}}$ (For Beams) $=$ $\left.\begin{matrix} \frac{1.1}{F_y} b\, d \\ 1.3\, A_{s\,req.} \end{matrix}\right\}$ الأقل $\left.\begin{matrix} \\ \\ \end{matrix}\right\}$ الأكبر

st. 360/520 $\frac{0.15}{100}$ b d

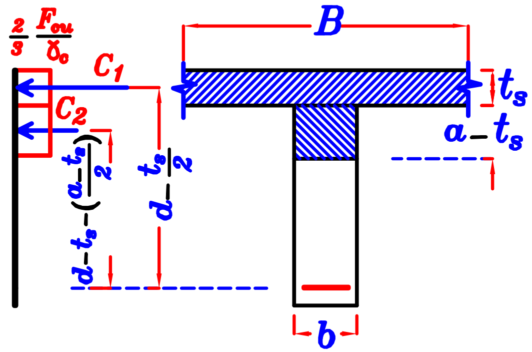
st. 240/350 $\frac{0.25}{100}$ b d

IF $M_{U.L.} > M_{Flange}$

حالة نادره

$\therefore a > t_s$

$\therefore$ Get a From



$$M_{U.L.} = \frac{2}{3} \frac{F_{cu}}{\delta_c} t_s B (d - \frac{t_s}{2}) + \frac{2}{3} \frac{F_{cu}}{\delta_c} (a - t_s)\, b\, [d - t_s - (\frac{a - t_s}{2})]$$

Get A_s From $\frac{2}{3} \frac{F_{cu}}{\delta_c} t_s B + \frac{2}{3} \frac{F_{cu}}{\delta_c} (a - t_s)\, b = A_s \frac{F_y}{\delta_s}$

ملحوظه هذه الحالة نادره جدا

و ممكن اهمالها و أخذ $a = t_s$

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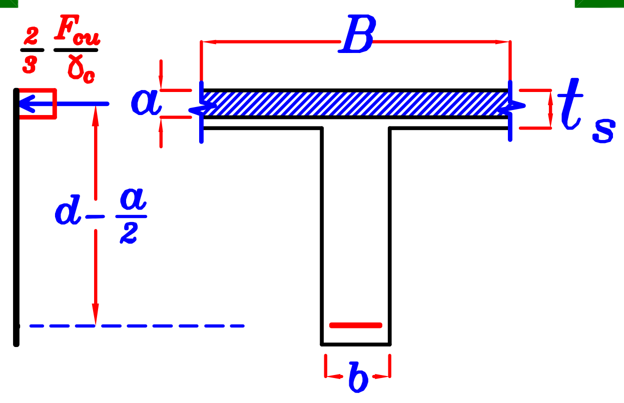
2 – IF d is not given.

Design of T–sec. & L–sec. subjected to B.M. only

Get B For the Sec.
assume d or a

$$\boxed{a \leqslant t_s}$$



IF d is given or d is assumed

$\therefore$ From

$$M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, a\, B\left(d-\frac{a}{2}\right)$$

Get $\boxed{a}$

IF $a \leqslant 0.1\, d$

$\therefore$ Take $a = 0.1\, d$

– Get A_s From

$$M_{U.L.} = A_s \frac{F_y}{\gamma_s}\left(d-\frac{0.1\, d}{2}\right)$$

IF $a > 0.1\, d$

Get A_s

From $\frac{2}{3}\frac{F_{cu}}{\gamma_c} * a * B = A_s * \frac{F_y}{\gamma_s}$

– Check $A_{s_{min.}}$ (For Beams)

$$A_{s_{min.}} = \left.\begin{cases}\left.\begin{array}{l}\frac{1.1}{F_y}\, b\, d \\ 1.3\, A_{s\,req.}\end{array}\right\} \text{الأقل} \\ st.\ 360/520 \quad \frac{0.15}{100}\, b\, d \\ st.\ 240/350 \quad \frac{0.25}{100}\, b\, d\end{cases}\right\} \text{الأكبر}$$

IF a is assumed $a \simeq (0.8 \rightarrow 1.0)\ t_s$

From

$$M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c}\, a\, B\left(d-\frac{a}{2}\right)$$

Get $\boxed{a}$

IF $a \leqslant 0.1\, d$

$\therefore$ Take $a = 0.1\, d$

– Get A_s From

$$M_{U.L.} = A_s \frac{F_y}{\gamma_s}\left(d-\frac{0.1\, d}{2}\right)$$

IF $a > 0.1\, d$

Get A_s

From $\frac{2}{3}\frac{F_{cu}}{\gamma_c} * a * B = A_s * \frac{F_y}{\gamma_s}$

– Check $A_{s_{min.}}$ (For Beams)

$$A_{s_{min.}} = \left.\begin{cases}\left.\begin{array}{l}\frac{1.1}{F_y}\, b\, d \\ 1.3\, A_{s\,req.}\end{array}\right\} \text{الأقل} \\ st.\ 360/520 \quad \frac{0.15}{100}\, b\, d \\ st.\ 240/350 \quad \frac{0.25}{100}\, b\, d\end{cases}\right\} \text{الأكبر}$$

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Example.

$F_{cu} = 25\ N\backslash mm^2$, st. 360/520

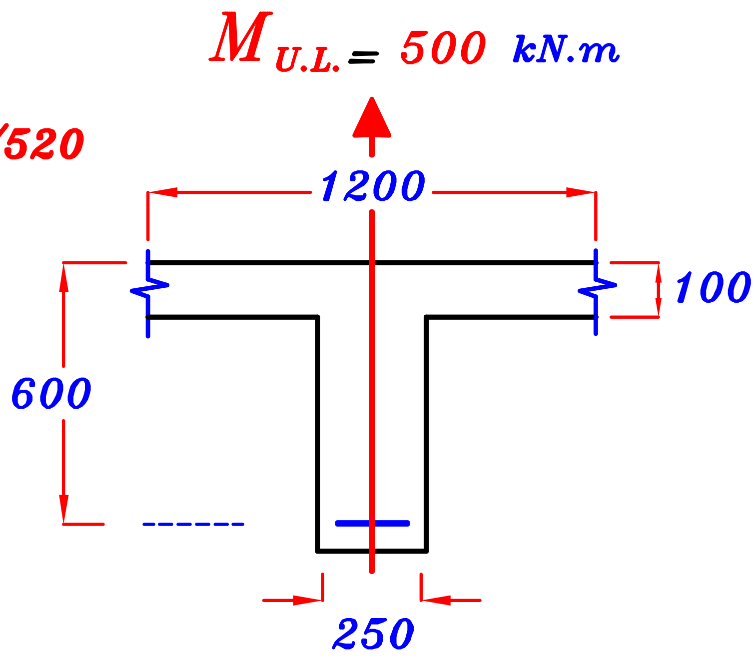
$b = 250\ mm$

$B = 1200\ m$

$d = 600\ m$

$M_{U.L.} = 500\ kN.m$

Get A_s



$$- M_{Flange} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} t_s B \left(d - \frac{t_s}{2}\right) = \frac{2}{3}\left(\frac{25}{1.5}\right)(100)(1200)\left(600 - \frac{100}{2}\right)$$

$$= 733333333\ N.mm = 733.33\ kN.m$$

$$\therefore M_{U.L.} < M_{Flange} \longrightarrow a < t_s$$

$$- \text{Get } a \text{ From } M_{U.L.} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} a B \left(d - \frac{a}{2}\right)$$

$$\therefore 500 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(a)(1200)\left(600 - \frac{a}{2}\right) \longrightarrow a = 66.14\ mm$$

$$\therefore a > 0.1\ d \xrightarrow{Get} A_s \xrightarrow{From} \frac{2}{3} \frac{F_{cu}}{\gamma_c} * a * B = A_s * \frac{F_y}{\gamma_s}$$

$$\frac{2}{3}\left(\frac{25}{1.5}\right)(66.14)(1200) = A_s \left(\frac{360}{1.15}\right) \longrightarrow \boxed{A_s = 2817\ mm^2}$$

$$- \text{Check } A_{s_{min.}} = \frac{1.1}{F_y} b\, d = \frac{1.1}{360}(250)(600) = 458\ mm^2$$

$$\therefore A_{s_{min.}} < A_s = 2817\ mm^2$$

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Example.

$F_{cu} = 25\ N\backslash mm^2$, st. $360/520$

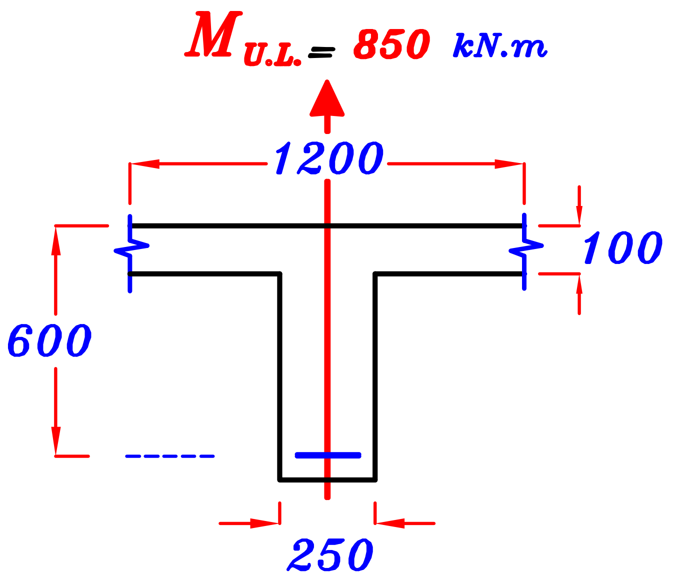
$b = 250\ mm$

$B = 1200\ m$

$d = 600\ m$

$M_{U.L.} = 850\ kN.m$

Get A_s

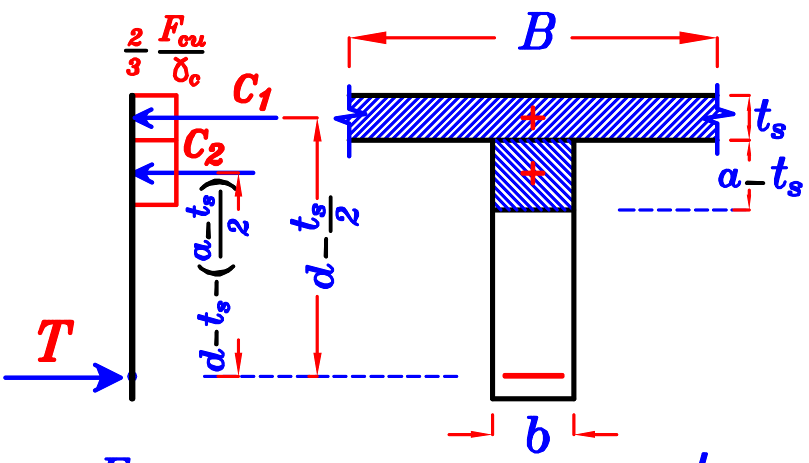


$$- M_{Flange} = \frac{2}{3}\frac{F_{cu}}{\gamma_c} t_s\, B\left(d - \frac{t_s}{2}\right) = \frac{2}{3}\left(\frac{25}{1.5}\right)(100)(1200)\left(600 - \frac{100}{2}\right)$$

$$= 733333333\ N.mm = 733.33\ kN.m$$

$\therefore M_{U.L.} > M_{Flange}$

$\therefore \boxed{a > t_s}$



$\therefore$ Get a From

$$M_{U.L.} = \frac{2}{3}\frac{F_{cu}}{\gamma_c} t_s\, B\left(d - \frac{t_s}{2}\right) + \frac{2}{3}\frac{F_{cu}}{\gamma_c}(a - t_s)\, b\left[d - t_s - \left(\frac{a - t_s}{2}\right)\right]$$

$$850 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(100)(1200)\left(600 - \frac{100}{2}\right) + \frac{2}{3}\left(\frac{25}{1.5}\right)(a - 100)(250)\left[600 - 100 - \left(\frac{a - 100}{2}\right)\right]$$

$\therefore \boxed{a = 450.39\ mm}$

Get A_s From $\quad \frac{2}{3}\frac{F_{cu}}{\gamma_c} t_s B + \frac{2}{3}\frac{F_{cu}}{\gamma_c}(a - t_s)\, b = A_s \frac{F_y}{\gamma_s}$

$$\therefore \frac{2}{3}\left(\frac{25}{1.5}\right)(100)(1200) + \frac{2}{3}\left(\frac{25}{1.5}\right)(450.39 - 100)(250) = A_s\left(\frac{360}{1.15}\right)$$

$\therefore \boxed{A_s = 7368.4\ mm}$

$-$ Check $A_{s\,min.} = \frac{1.1}{F_y}\, b\, d = \frac{1.1}{360}(250)(600) = 458\ mm^2$

$\therefore A_{s\,min.} < A_s = 7368.4\ mm^2$

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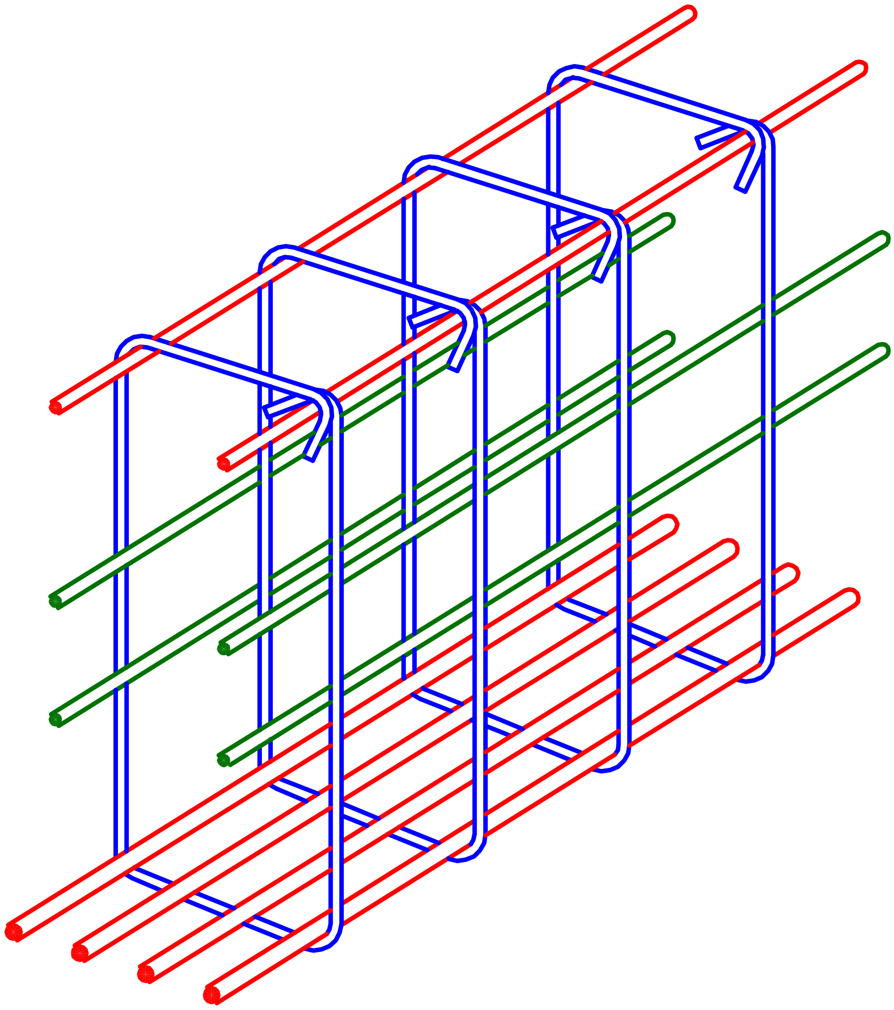
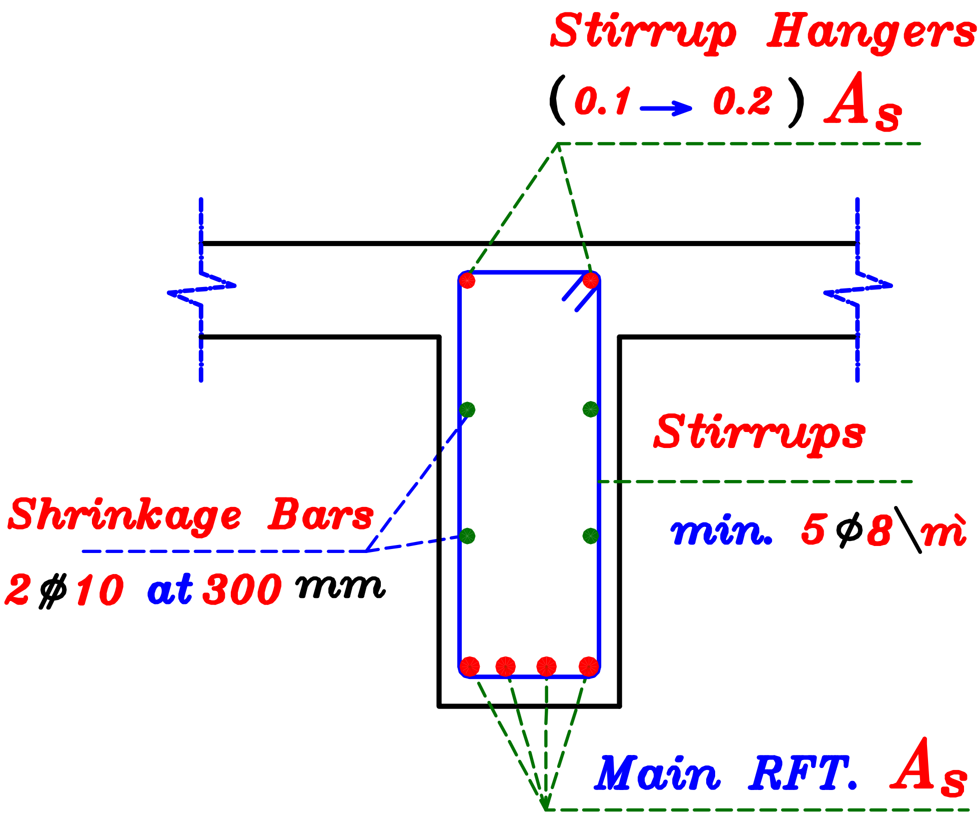
Reinforcement in Cross section.

رسم التسليح داخل قطاع الكمره





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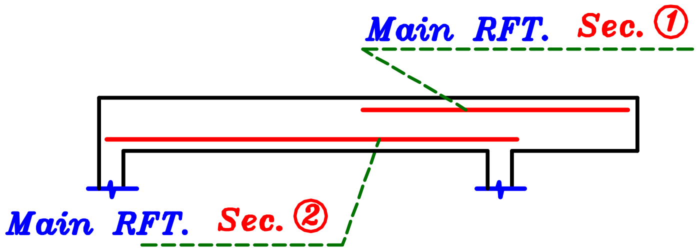
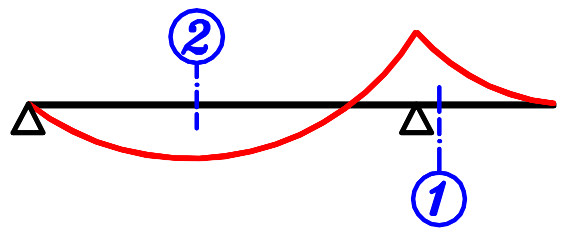
① Main RFT. (A_s)





هو الحديد الرئيسى الموجود فى القطاع و يكون دائما جهه الشد أى يكون جهه ال **moment**

Choosing A_s

* min ϕ = ϕ 12 * max ϕ = ϕ 25
* max. No. of rows = 3 rows أكبر عدد لصفوف التسليح يساوى ٣ صفوف .
* min. No. of bars in one row = 2 bars أقل عدد أسياخ فى الصف الواحد تساوى ٢ سيخ .
* max. No. of bars in one row = n bar

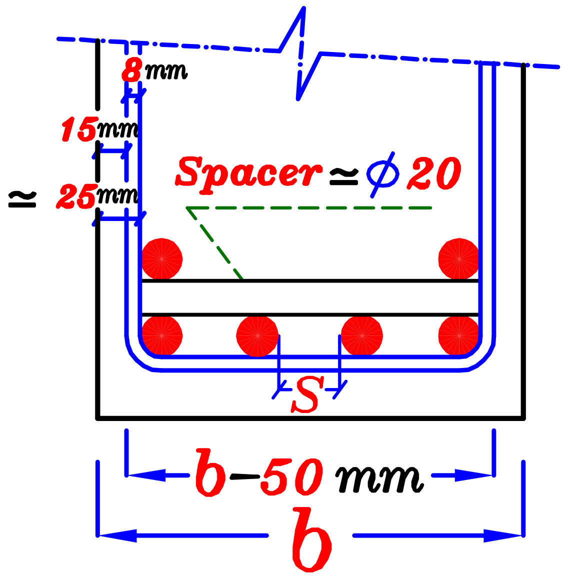
أكبر عدد أسياخ ممكن وضعها فى الصف الواحد تساوى n

Calculation of max. No. of bars in one raw.

To get n , we have to get min. spacing between bars (S)

$$S = \left\{ \begin{array}{l} 25 \text{ mm} \\ \phi_{max} \\ \text{max. size of aggregate} + 5 \text{ m.m.} \end{array} \right\}$$ الأكبر $\simeq$ 25 mm

Take $\boxed{S = 25 \text{ mm}}$



$$b - 50 = n\,\phi + (n-1)(S)$$

$$\therefore\ b - 50 = n\,\phi + (n-1)(25)$$

$$\therefore\ b - 50 = n\,(\phi + 25) - 25$$

$$\boxed{n = \frac{b-25}{\phi+25}}$$ حفظ

Example.

$b = 250$ mm , $\phi\ 16 = 16$ mm

$$\therefore\ n = \frac{b-25}{\phi+25} = \frac{250-25}{16+25} = 5.48 = 5.0 \text{ bars in one row.}$$

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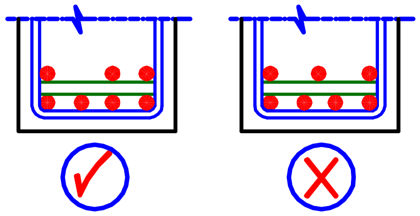
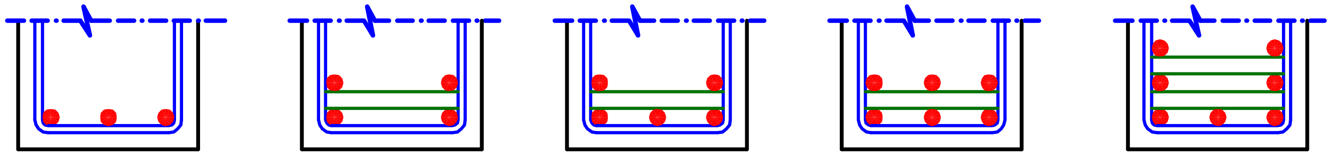
عند وجود أكثر من صف تسليح فى الكمره .
يجب أن يكون كل سيخ فى الصف العوى
يكون أسفلة سيخ فى الصف السفلى.

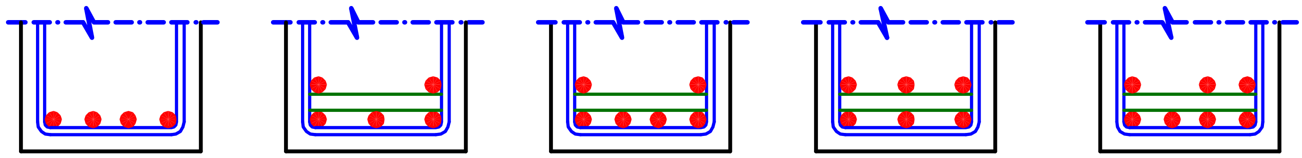


IF $n = 3$



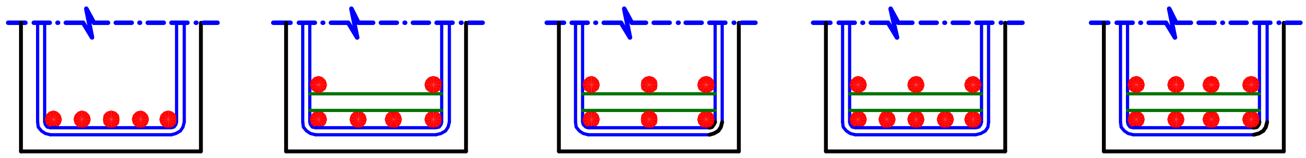
3 Bars | 4 Bars | 5 Bars | 6 Bars | 7 Bars

IF $n = 4$



3 Bars | 4 Bars | 5 Bars | 6 Bars | 7 Bars
not a Symmetric Sec.

IF $n = 5$

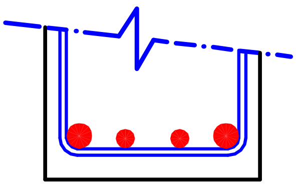


5 Bars | 6 Bars | 7 Bars | 8 Bars | 9 Bars

---

* ممكن استخدام قطرين مختليفين فى الكمره بشروط .

- أن يكونا متتاليان فى الجدول 12،16،18،20،22،25
- توضع الأسياخ ذات القطر الأكبر فى الأركان.
- نحاول على قدر الأمكان أن يكون القطاع *Symmetric* .
- أقل عدد من الأسياخ من كل قطر = ٢ سيخ .



2∅16+ 2∅18

Example.

3∅12 ------------- (✓)
2∅12 + 2∅16 ------ (✓)
2∅12 + 1∅16 ------ (✗)
2∅12 + 3∅16 ------ (✓)
2∅12 + 2∅18 ------ (✗)

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Area of Steel

$$A_s = \checkmark \ mm^2$$

ϕ \ No.	1	2	3	4	5	6	7	8	9	10	11	12
6	28.3	56.6	84.9	113.2	141.5	169.8	198.1	226.4	198.1	283	311.3	339.6
8	50.3	100.6	150.9	201.2	251.5	301.8	352.1	402.4	452.7	503	553.3	603.6
10	78.5	157	235.5	314	392.5	471	549.5	628	706.5	785	863.5	942
12	113	226	339	452	565	678	791	904	1017	1130	1243	1356
13	133	266	399	532	665	798	931	1064	1197	1330	1463	1596
16	201	402	603	804	1005	1206	1407	1608	1809	2010	2211	2412
18	254	508	762	1016	1270	1524	1778	2032	2286	2540	2794	3048
19	283	566	849	1132	1415	1698	1981	2264	2547	2830	3113	3396
20	314	628	942	1256	1570	1884	2198	2512	2826	3140	3454	3768
22	380	760	1140	1520	1900	2280	2660	3040	3420	3800	4180	4560
25	491	982	1473	1964	2455	2946	3437	3928	4419	4910	5401	5892
28	616	1232	1848	2464	3080	3696	4312	4928	5544	6160	6776	7392

الاقطار المشهوره فى مصر الوقت الحالى

ϕ \ No.	1	2	3	4	5	6	7	8	9	10	11	12
8	50.3	100.6	150.9	201.2	251.5	301.8	352.1	402.4	452.7	503	553.3	603.6
10	78.5	157	235.5	314	392.5	471	549.5	628	706.5	785	863.5	942
12	113	226	339	452	565	678	791	904	1017	1130	1243	1356
16	201	402	603	804	1005	1206	1407	1608	1809	2010	2211	2412
18	254	508	762	1016	1270	1524	1778	2032	2286	2540	2794	3048
20	314	628	942	1256	1570	1884	2198	2512	2826	3140	3454	3768
22	380	760	1140	1520	1900	2280	2660	3040	3420	3800	4180	4560
25	491	982	1473	1964	2455	2946	3437	3928	4419	4910	5401	5892

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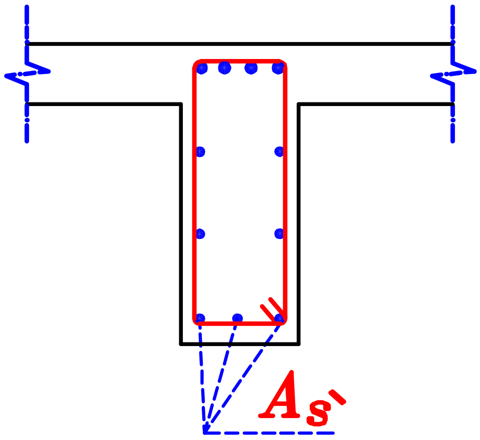
② Compressive Steel (A_s')



R–Sec.

و هو الحديد الذى يوضع فى منطقة الضغط إذا ما إحتاج القطاع إلى ذلك .

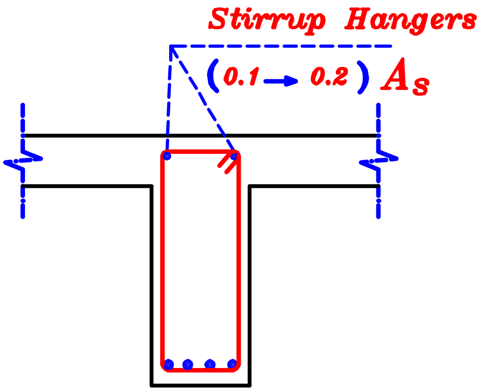
ممكن وضع الـ A_s' فى الـ **R–Sec.** فقط

و لا يمكن وضعة فى الـ **T–Sec. & L–Sec.**

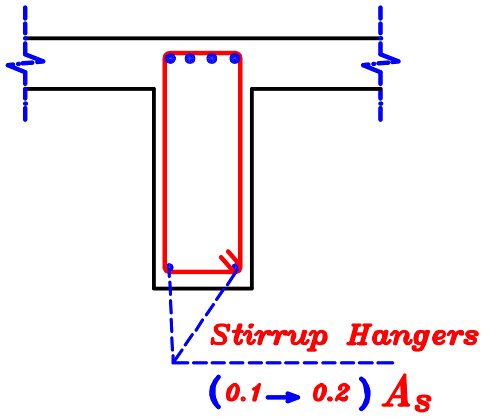
$$\boxed{A_{s'\,max.} = 0.40\ A_s}$$

---

③ Stirrup Hangers. تعليق الكانات



T–Sec.



R–Sec.

- هى أسياخ توضع فى جهه الضغط إذا لم نحتاج الى A_s' .
- وظيفتها هى تعليق الكانات عليها لذا تسمى **Stirrup Hangers** .
- تعتبر الـ **Stirrup Hangers** عباره عن **Secondary Steel** . أى أننا نهمل وجودها فى الحسابات .
- توضع الـ **Stirrup Hangers** فى كلاً من **R–Sec. & L–Sec. & T–Sec.**
- قيمه الـ **Stirrup Hangers** فى القطاع تكون الأكبر من .

$$\left.\begin{array}{ll} (0.1 \rightarrow 0.2)\ A_s & \\ 2\phi 10 & \text{Beams} \\ 2\phi 12 & \text{Frames} \end{array}\right\}\ \text{الأكبر}$$

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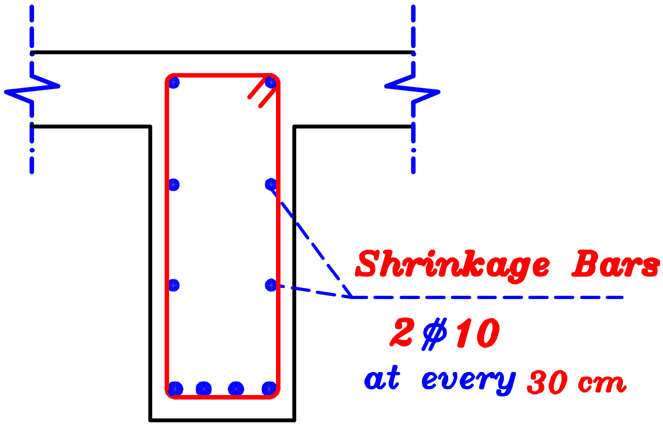
④ Shrinkage Bars.

- و هى عباره عن أسياخ حديد توضع فى جانبى الكمره لتقليل إنكماش الخرسانه



- و نحتاج الـ **Shrinkage Bars** فقط عندما تكون $t > 700$ mm

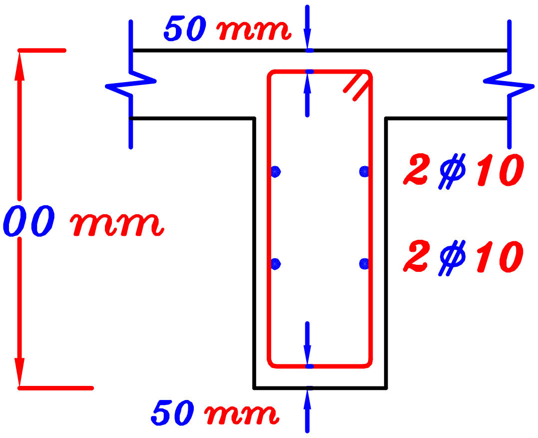
- قيمة الـ **Shrinkage Bars** هى الأكبر من
$$\begin{cases} 0.08\,A_s \\ 2\phi10 \text{ at every } 300\text{ mm} \end{cases}$$
✓✓

Example.

IF $t = 800$ mm

$$\therefore \text{No. of Spacings} = \frac{800-100}{300}$$

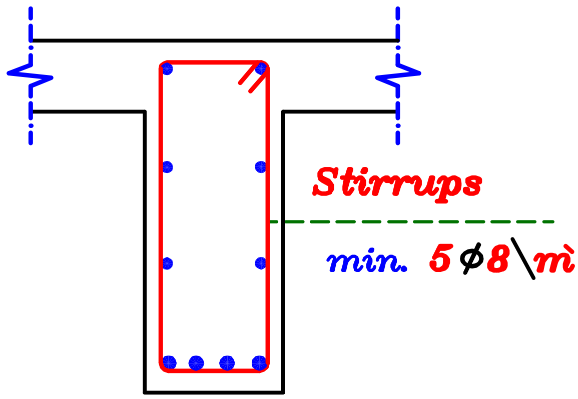
$$= 2.33 = 3.0 \text{ Spacing} \longrightarrow 2.0 \text{ Bars}$$



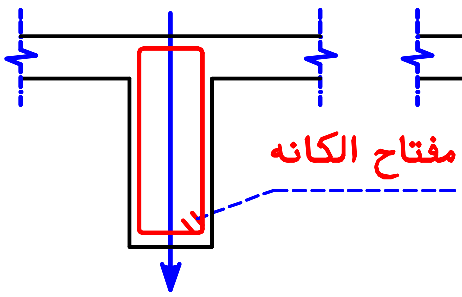
⑤ Stirrups. الكانات

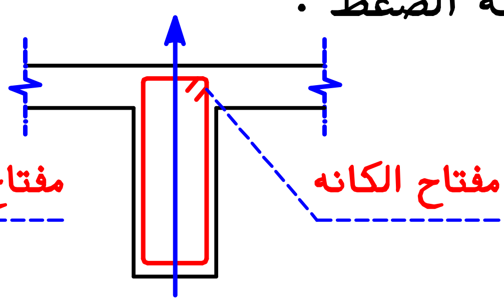
توضع الكانات فى الكمرات لـ

- مقاومه الـ **Shear Stress**.
- للربط بين الخرسانه فى منطقه الضغط و الحديد فى منطقه الشد.



- أقل قيمه للكانات فى الكمره هى $5\phi8\backslash m'$.
- مفتاح الكانه يكون دائما جهه الضغط .





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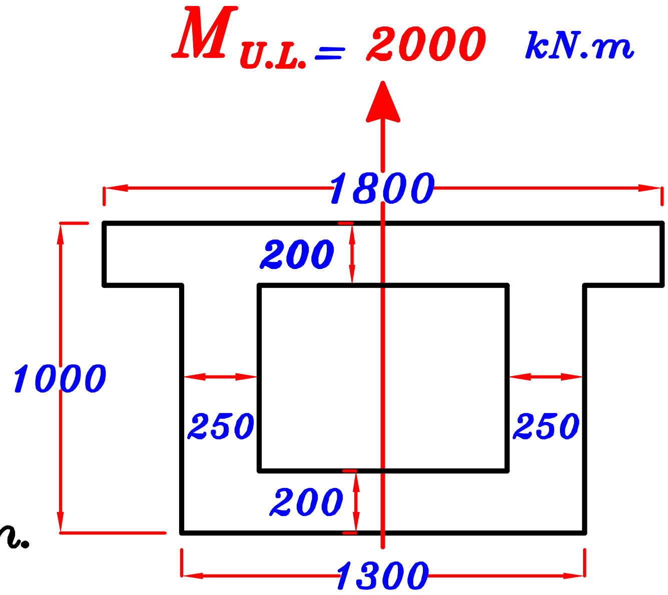
$F_{cu} = 25 \ N\backslash mm^2$

, st. 360/520

$M_{U.L.} = 2000 \ kN.m$

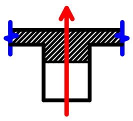
Design the section.

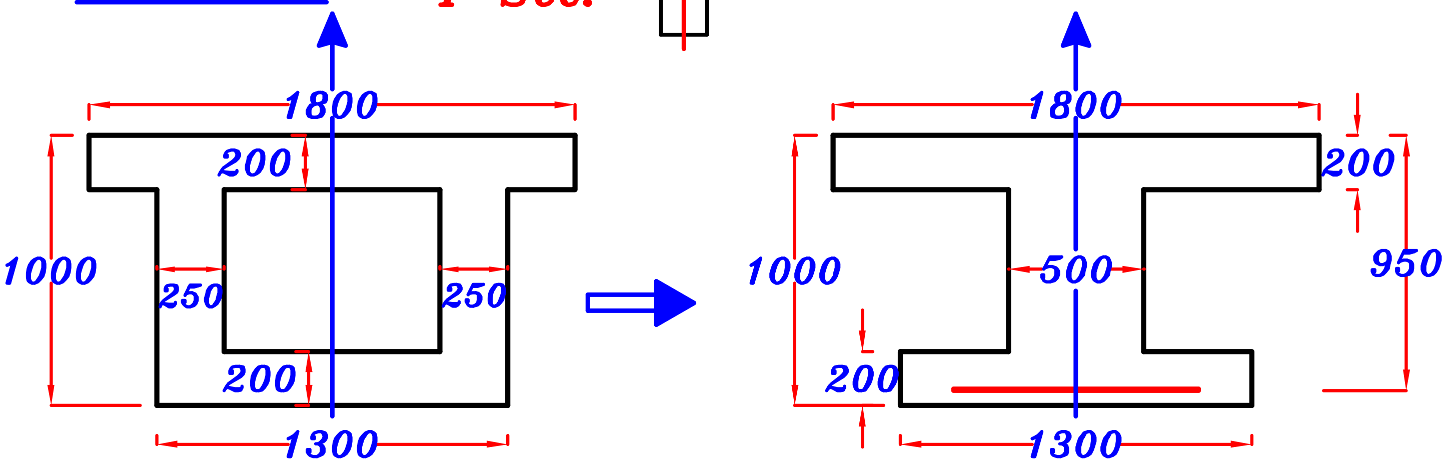
Draw details of RFT. in section.



Solution.

T-Sec.

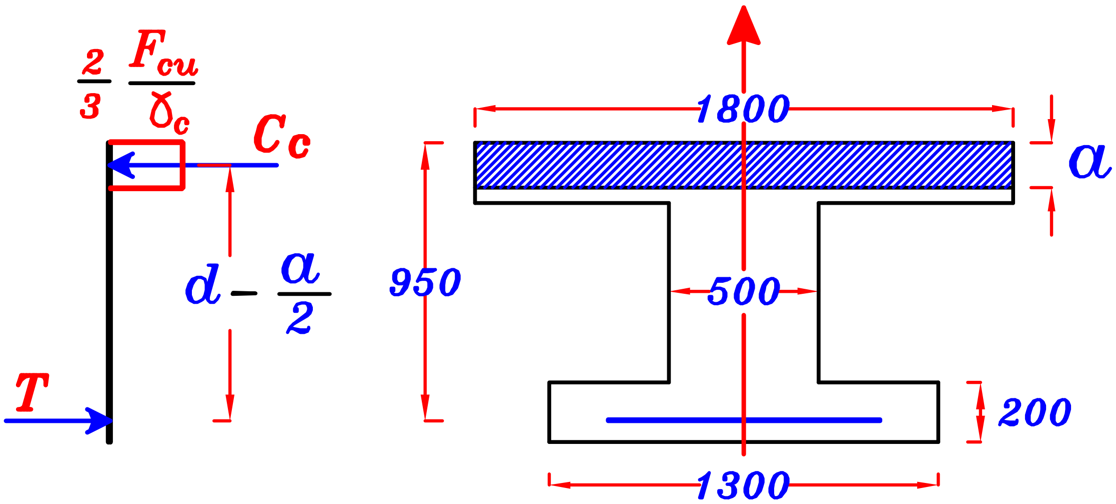




$$- M_{Flange} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} t_s B \left(d - \frac{t_s}{2}\right) = \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(1800)\left(950 - \frac{200}{2}\right)$$

$$= 3400000000 \ N.mm = 3400 \ kN.m$$

$$\therefore M_{U.L.} < M_{Flange} \longrightarrow a < t_s$$



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– Get a From $M_{U.L.} = \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\,a\,B\left(d - \frac{a}{2}\right)$

$\therefore 2000 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(a)(1800)\left(950 - \frac{200}{2}\right) \longrightarrow a = 117.6 \text{ mm}$

$\therefore a > 0.1\,d$

Get A_s From Compression Force = Tension Force

$\boxed{C_c = T}$ $\quad \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\,a\,B = A_s * \frac{F_y}{\gamma_s}$

$\therefore \frac{2}{3}\left(\frac{25}{1.5}\right)(117.6)(1800) = A_s * \left(\frac{360}{1.15}\right)$

$\therefore A_s = 7513.3 \text{ mm}^2$ $\quad 20\phi22$

– Check $A_{s_{min.}} = \frac{1.1}{F_y}\,b\,d = \frac{1.1}{360}(500)(950) = 1451 \text{ mm}^2$

$\therefore A_{s_{min.}} < A_s = 7513.3 \text{ mm}^2$

$\therefore n = \frac{b - 25}{\phi + 25} = \frac{1300 - 25}{22 + 25} = 27.1 = 27.0$

Stirrup Hangers $= (0.1 \rightarrow 0.2)\,A_s = (0.1 \rightarrow 0.2)\,7513.3$ $\quad 10\phi12$

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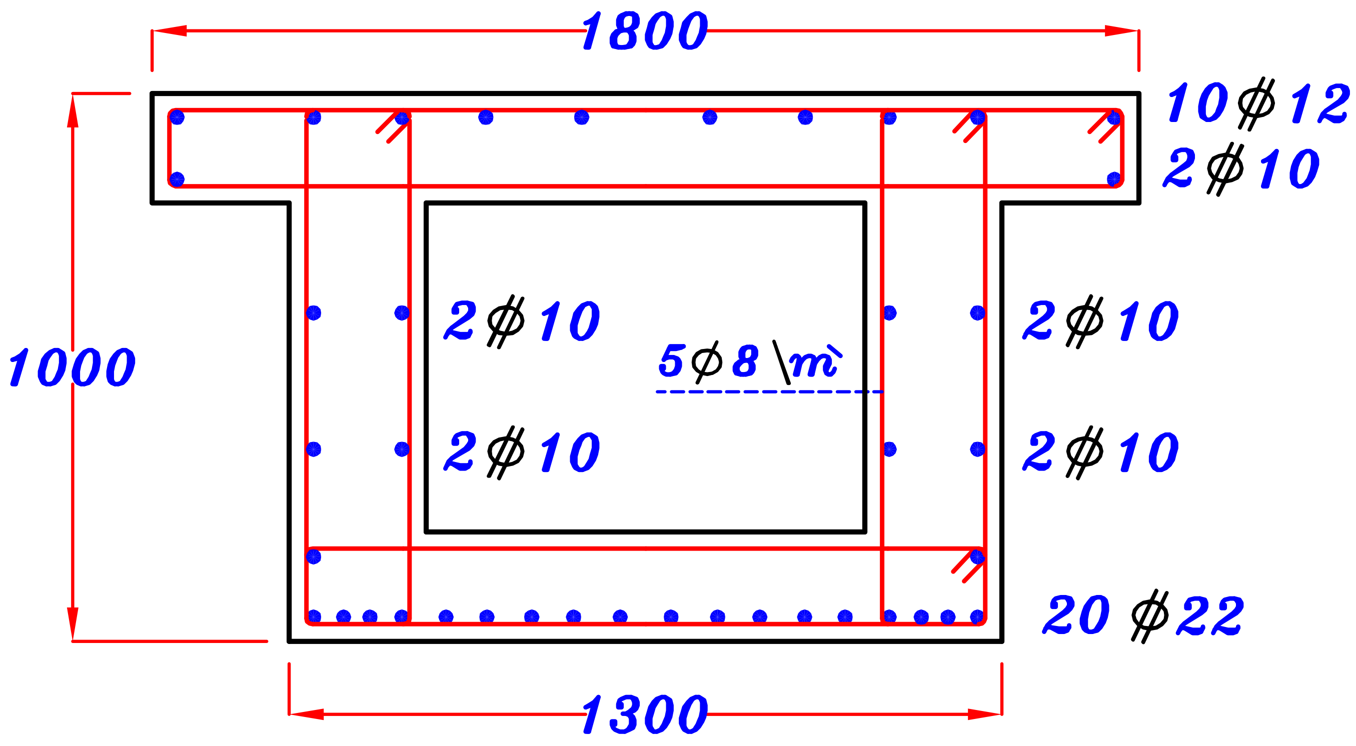
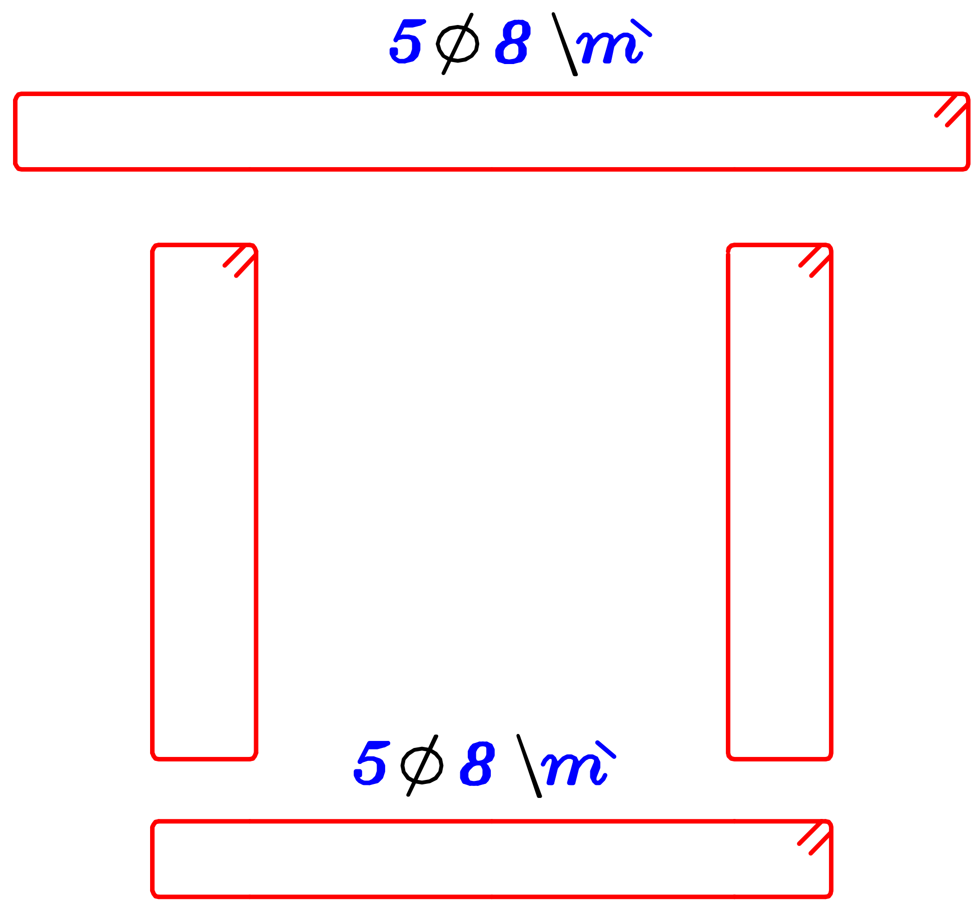
$A_s = 20\phi 22$

Stirrup Hangers = $10\phi 12$





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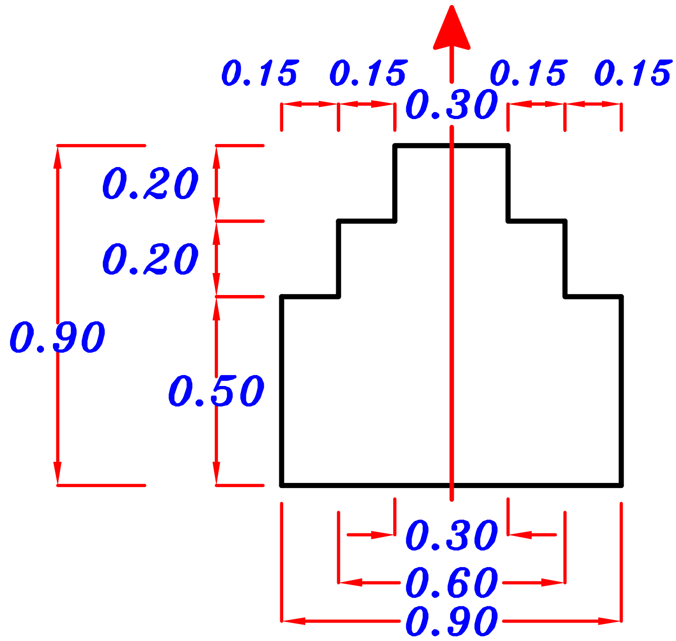
Example.

$F_{cu} = 25 \ N\backslash mm^2$

, st. 360/520

$M_{U.L.} = 250 \ kN.m$

Get A_s

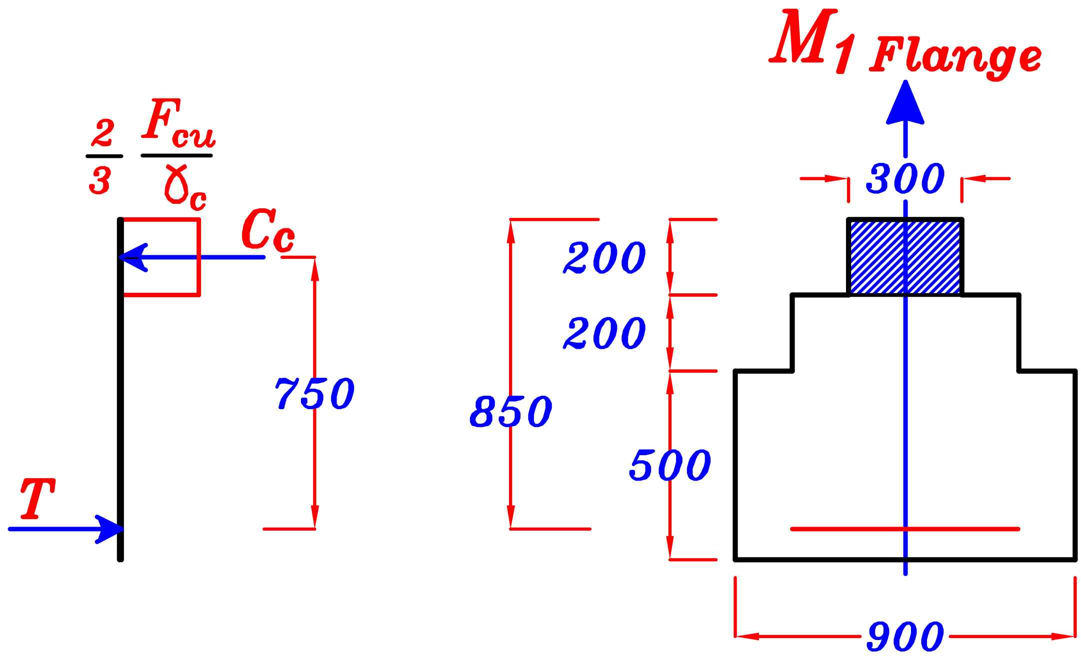


Solution.

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \gamma_s)}\right] * d = 0.35\, d = 0.35 * 850 = 297.5 \ mm$$

assume

$a = 200 \ mm$



$$- M_{1\,Flange} = \frac{2}{3}\frac{F_{cu}}{\gamma_c} t_s\, b\, (750) = \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(300)(750)$$

$$= 500000000 \ N.mm = 500 \ kN.m$$

$$\therefore M_{U.L.} > M_{Flange} \longrightarrow a > 200 \ mm$$

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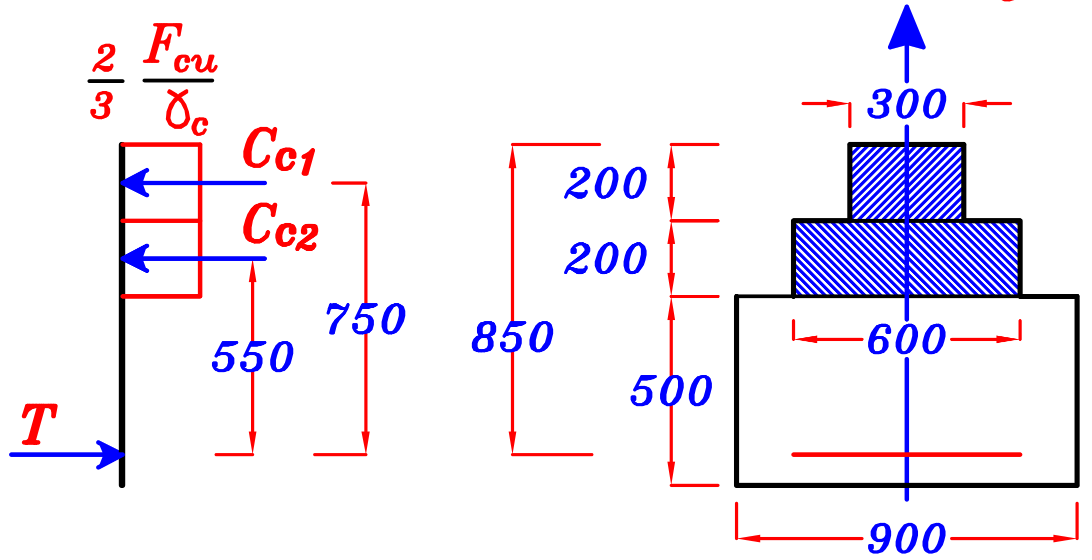
assume

$a = 400\ mm$

$M_{2\ Flange}$

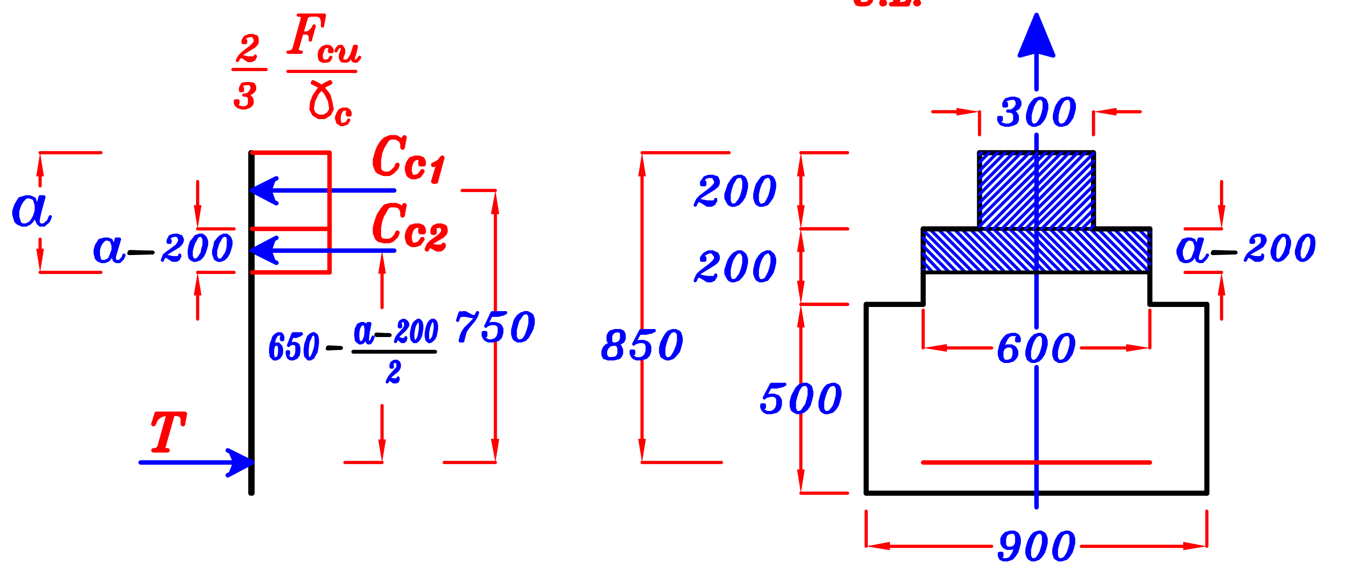


$$-M_{2\ Flange} = \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(300)(750) + \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(600)(550)$$

$$= 1233333333\ N.mm = 1233.3\ kN.m$$

$$\because\ M_{1\ Flange} < M_{U.L.} < M_{2\ Flange} \quad \therefore\ \boxed{200\ mm < a < 400\ mm}$$

$M_{U.L.} = 600\ kN.m$



$$C_{c1} = \frac{2}{3}\ \frac{F_{cu}}{\gamma_c}(200)(300) = \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(300)$$

$$C_{c2} = \frac{2}{3}\ \frac{F_{cu}}{\gamma_c}(a-200)(600) = \frac{2}{3}\left(\frac{25}{1.5}\right)(a-200)(600)$$

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Get a From

$$M_{U.L.} = C_{c1}(750) + C_{c2}\left(650 - \frac{a-200}{2}\right)$$

$$\therefore 600 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(300)(750) + \frac{2}{3}\left(\frac{25}{1.5}\right)(a-200)(600)\left(650 - \frac{a-200}{2}\right)$$

$\therefore a = 223\ mm$ $\qquad \therefore 0.1\,d < a < a_{max}$

Get A_s From Compression Force = Tension Force

$$\boxed{C_{c1} + C_{c2} = T}$$

$$\therefore \frac{2}{3}\left(\frac{25}{1.5}\right)(200)(300) + \frac{2}{3}\left(\frac{25}{1.5}\right)(223-200)(600) = A_s * \left(\frac{360}{1.15}\right)$$

$\therefore A_s = 2619.4\ mm^2$ $\qquad$ $7\phi 22$

– Check $A_{s_{min.}} = \frac{1.1}{F_y}\, b\, d = \frac{1.1}{360}(300)(850) = 779\ mm^2$

$\therefore A_{s_{min.}} < A_s = 2619.4\ mm^2$

$$\therefore n = \frac{b-25}{\phi + 25} = \frac{900-25}{22+25} = 18.6 = 18.0$$

Stirrup Hangers $= (0.1 \rightarrow 0.2)\,A_s = (0.1 \rightarrow 0.2)\,2619.4$

$4\phi 12$

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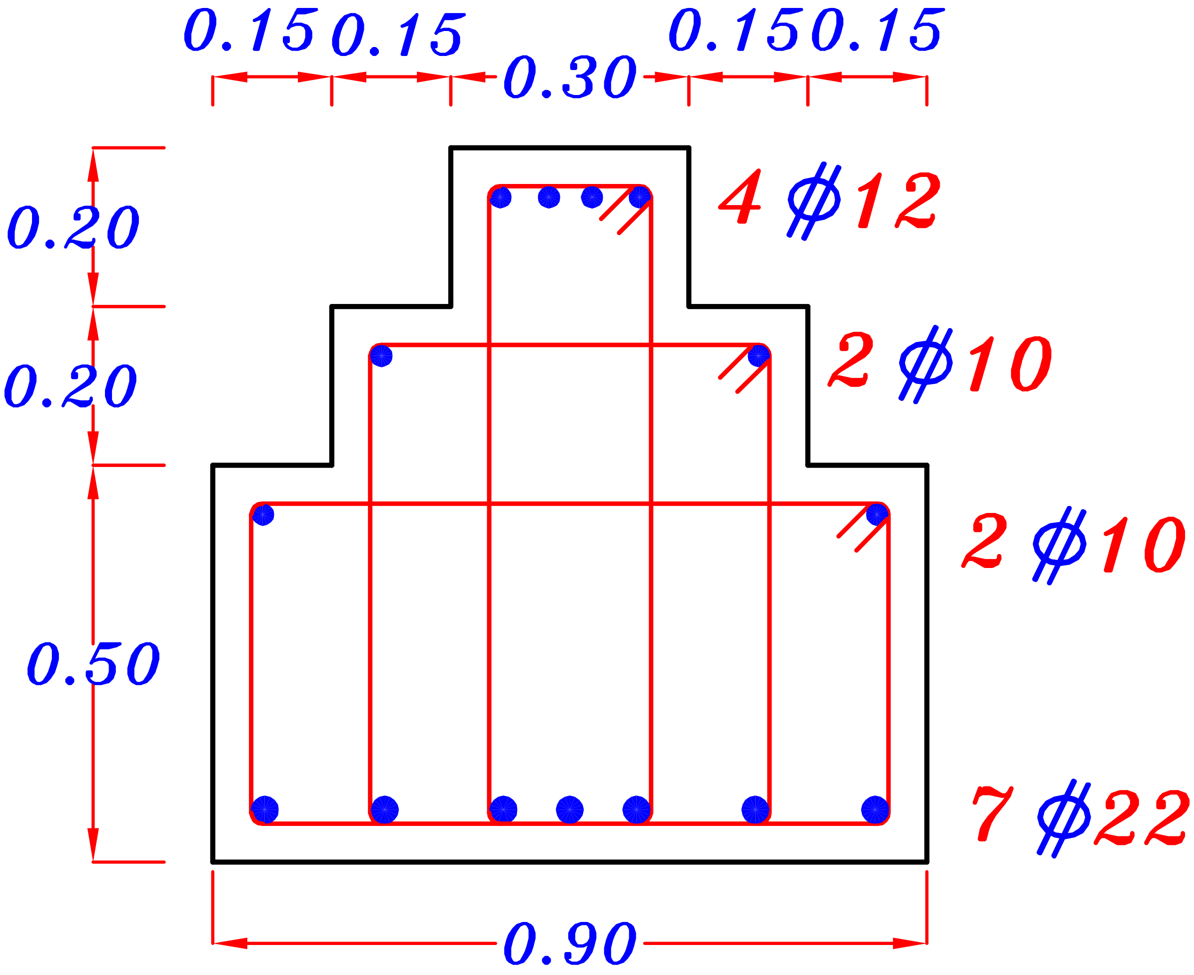

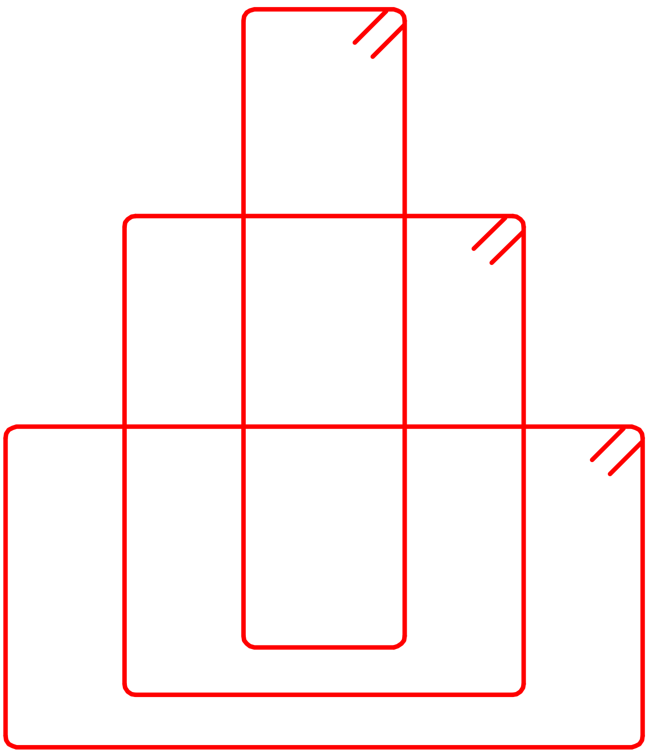

5 ϕ 8 \m`

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Example.

For the reinforced concrete simple girder carry the dead and live working loads and whose cross section is shown in Figure 1 It is required to:

1 – Using the First principles and the limit state design method, design the girder to satisfy the bending moment requirements.

2 – Draw the details of reinforcement of the girder's croos section to scale 1:25

Data : $F_{cu} = 25\ N\backslash mm^2$, st. 360/520

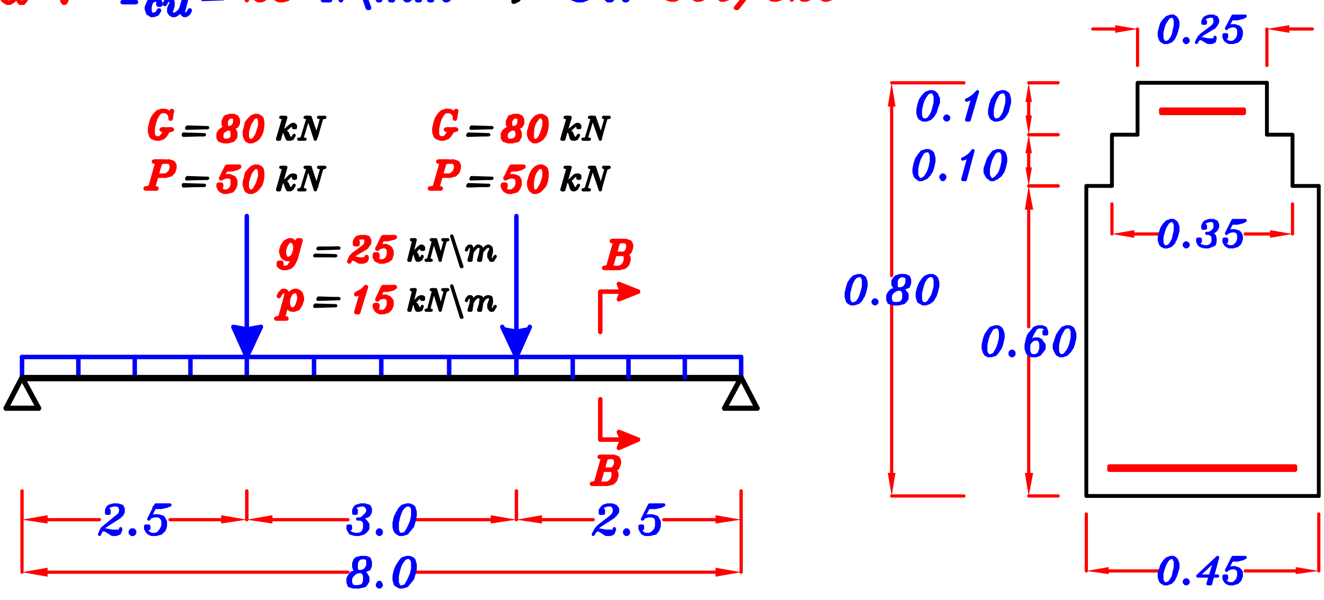
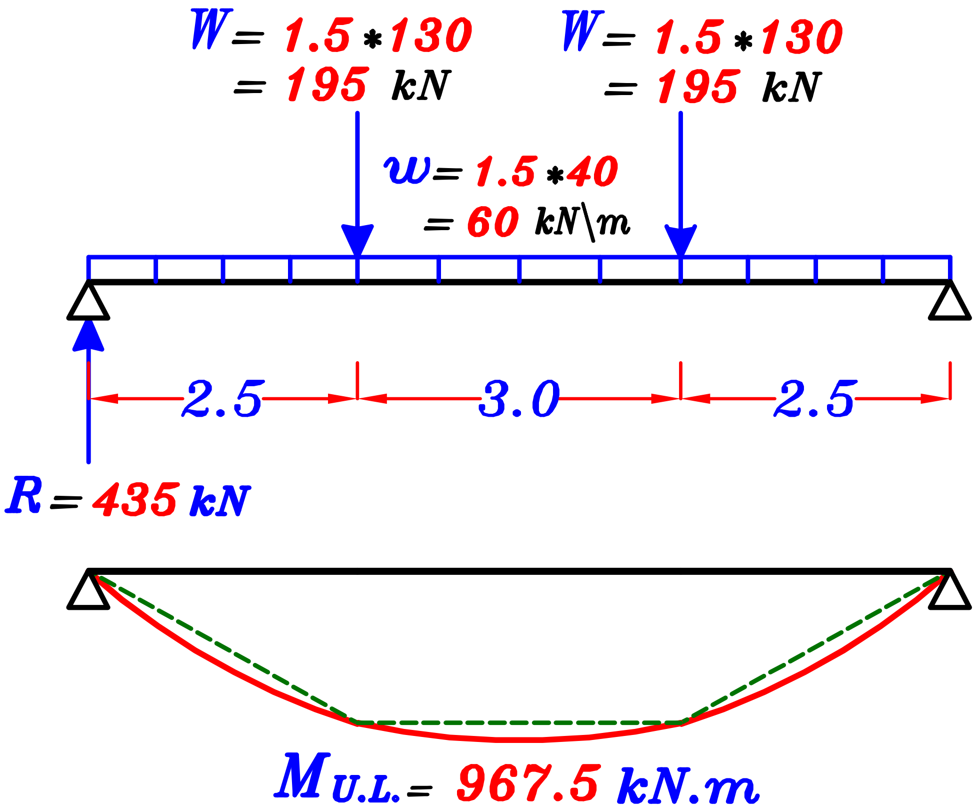


Figure 1



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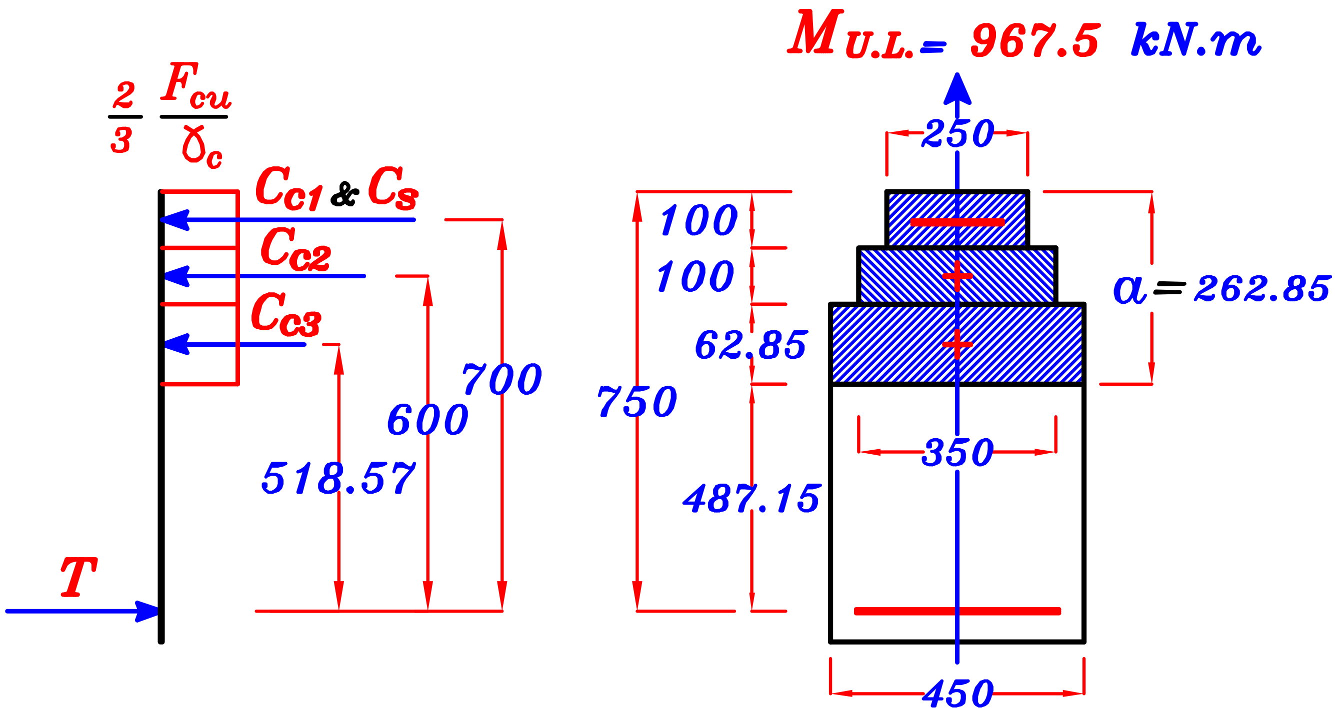
$\because$ $A_{s'}$ is given.

$$\therefore a = a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600+(F_y \backslash \gamma_s)}\right] d$$

$$\therefore a = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600+(360\backslash 1.15)}\right] 750 = 262.85 \text{ mm}$$



$$C_{c1} = \frac{2}{3}\left(\frac{25}{1.5}\right)(100)(250) = 277777.7 \text{ N} = 277.7 \text{ kN}$$

$$C_{c2} = \frac{2}{3}\left(\frac{25}{1.5}\right)(100)(350) = 388888.8 \text{ N} = 388.8 \text{ kN}$$

$$C_{c3} = \frac{2}{3}\left(\frac{25}{1.5}\right)(62.85)(450) = 314250 \text{ N} = 314.25 \text{ kN}$$

$$C_s = A_{s'} \frac{F_y}{\gamma_s} = A_{s'}\left(\frac{360}{1.15}\right) \quad , \quad T = A_s \frac{F_y}{\gamma_s} = A_s\left(\frac{360}{1.15}\right)$$

By taking the moment about tension steel.

$$* \; M_{U.L.} = C_s\,(700) + C_{c1}\,(700) + C_{c2}\,(600) + C_{c3}\,(518.57)$$

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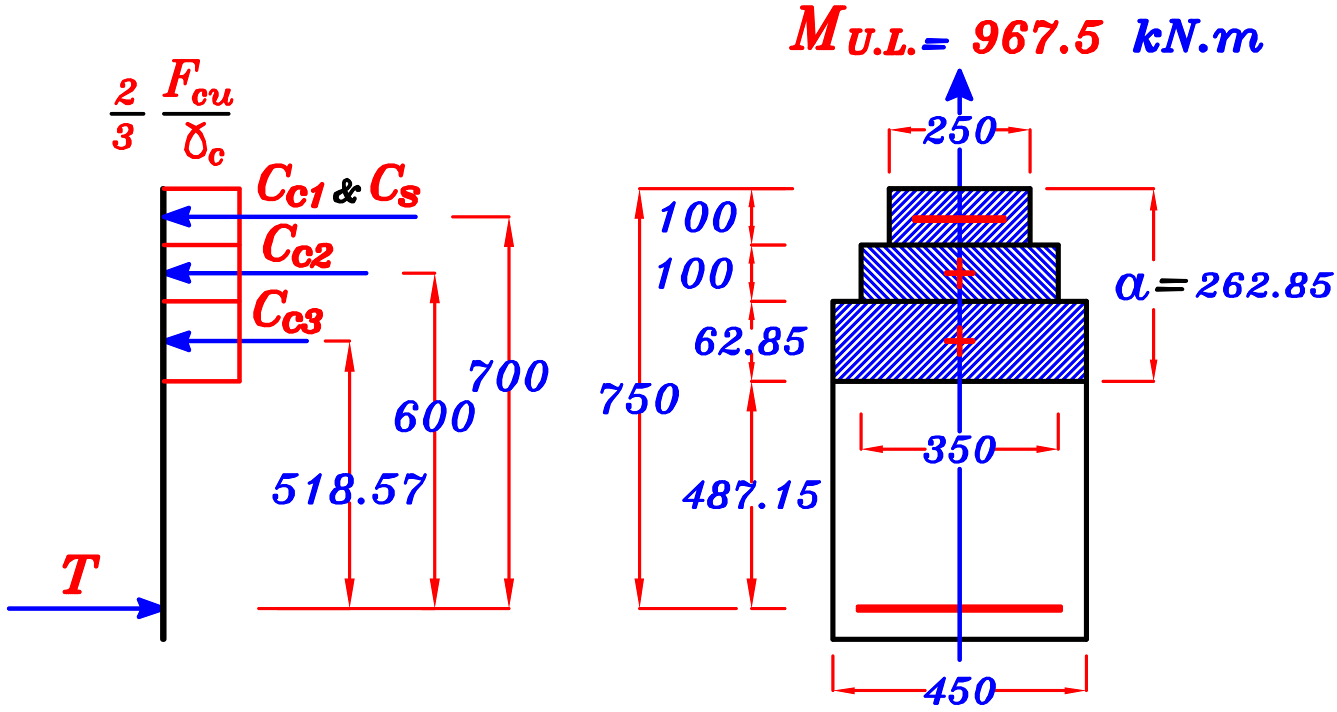
By taking the moment about tension steel.



$$* \; M_{U.L.} = C_s\,(700) + C_{c1}\,(700) + C_{c2}\,(600) + C_{c3}\,(518.57)$$

$$\therefore\; 967.5 * 10^6 = A_{s'}\left(\frac{360}{1.15}\right)(700) + 277777.7\,(700)$$

$$+\, 388888.8\,(600) + 314250\,(518.57) \longrightarrow \boxed{A_{s'} = 1719.34\ mm^2}$$

$$\therefore\; n = \frac{b-25}{\phi+25} = \frac{250-25}{22+25} = 4.78 = 4.0 \qquad 5\,\phi\,22$$

$$* \text{ Equilibrium equation. } \quad C_{c1} + C_{c2} + C_{c3} + C_s = T$$

$$\therefore\; 277777.7 + 388888.8 + 314250 + 1719.34\left(\frac{360}{1.15}\right) = A_s\left(\frac{360}{1.15}\right)$$

$$\longrightarrow \boxed{A_s = 4852.8\ mm^2} \qquad 10\,\phi\,25$$

$$n = \frac{b-25}{\phi+25} = \frac{450-25}{25+25} = 8.50 = 8.0$$

$$\text{Check} \quad \frac{A_{s'}}{A_s} = \frac{1719.34}{4852.8} = 0.354 < 0.4 \qquad \therefore \text{ o.k.}$$

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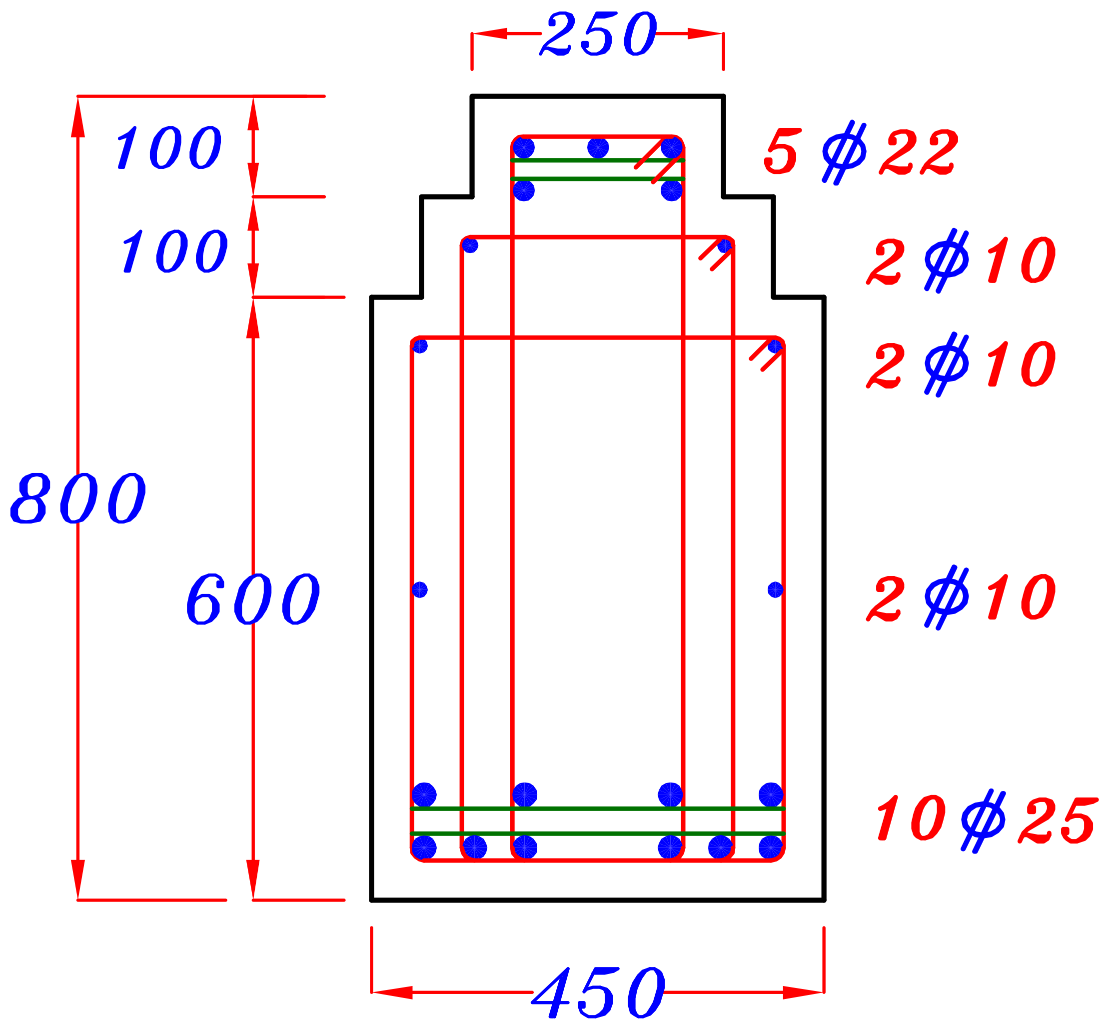

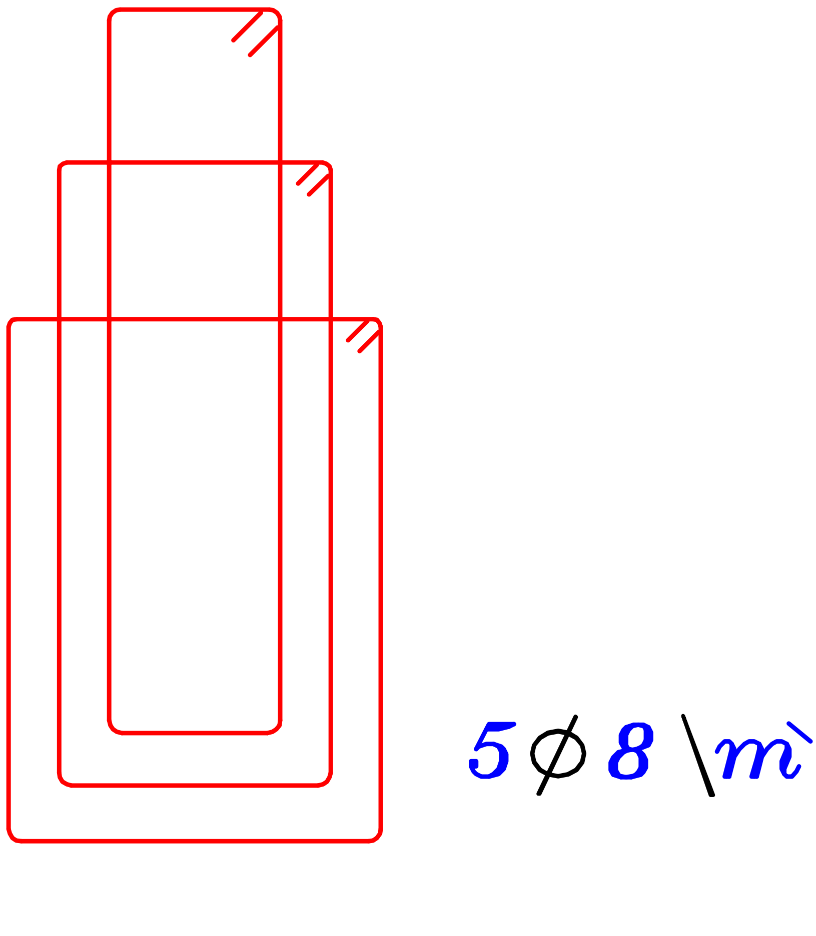

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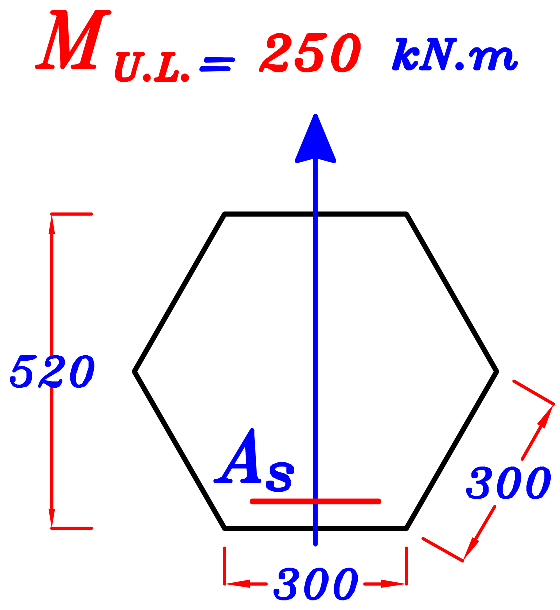
Example.

$F_{cu} = 25 \; N\backslash mm^2$

, st. 360/520

$M_{U.L.} = 250 \; kN.m$

Get A_s



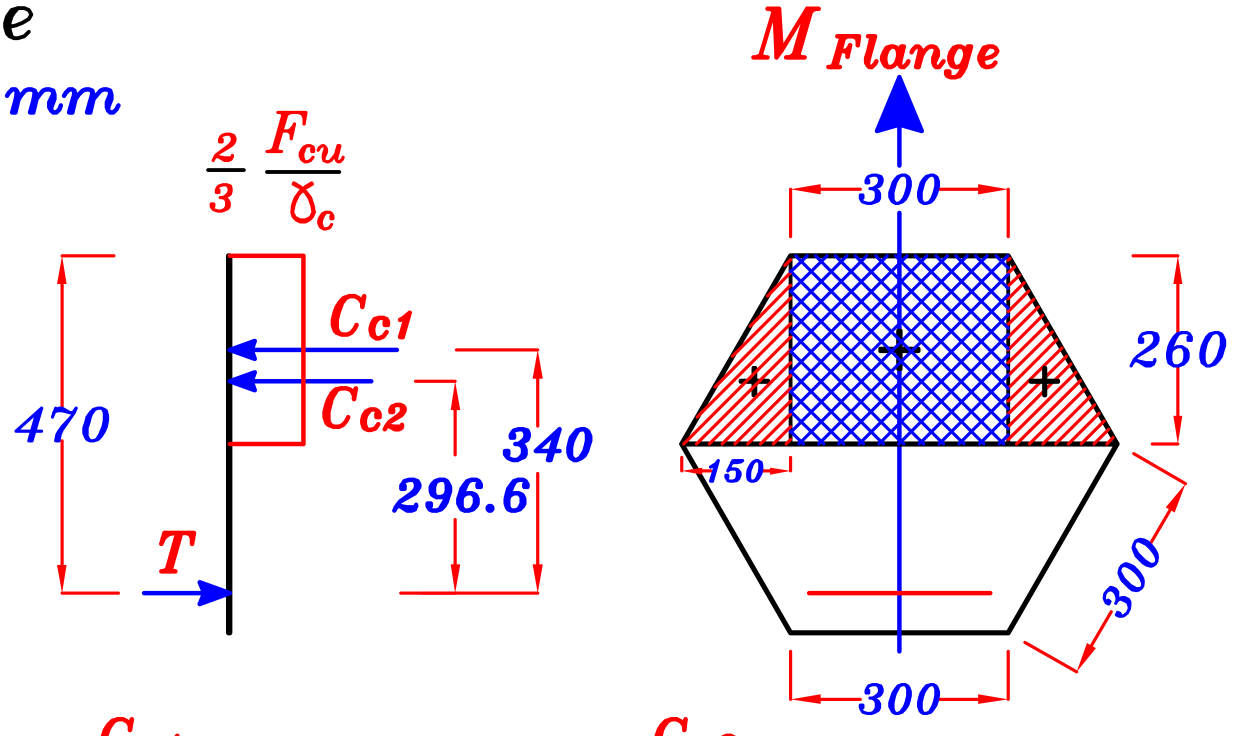
Solution.

$\because \; t = 520 \; mm \longrightarrow d = 470 \; mm$

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y\backslash \gamma_s)}\right] * d = 0.35\,d = 0.35 * 470 = 164.5 \; mm$$

Assume

$a = 260 \; mm$



$$\underset{Flange}{M} = \overset{C_{c1}}{\frac{2}{3}\left(\frac{25}{1.5}\right)(260)(300)\,[340]} + \overset{C_{c2}}{\frac{2}{3}\left(\frac{25}{1.5}\right) * 2(0.5)(150)(260)\,[296.6]}$$

$$= 423193333 \; N.mm = 423.19 \; kN.m$$

$$\therefore M_{U.L.} < M_{Flange} \longrightarrow a < 260 \; mm$$

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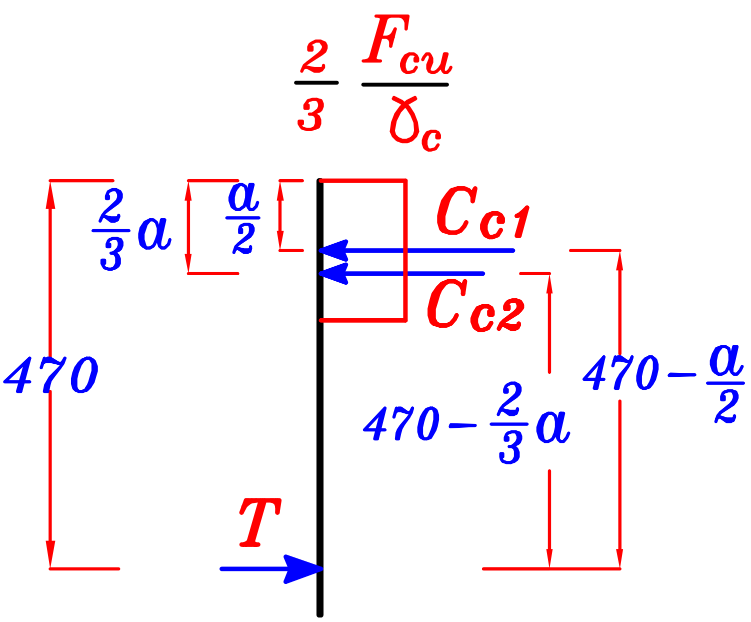
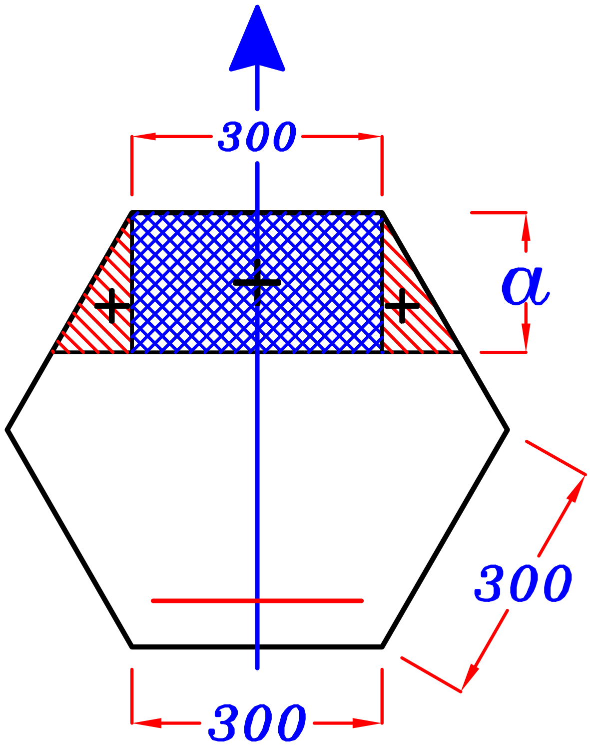
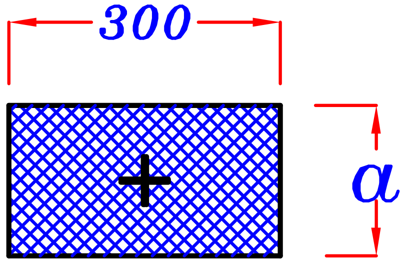
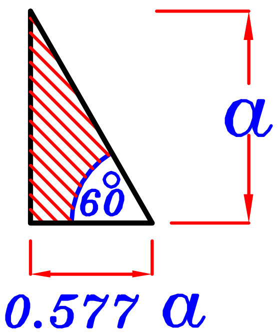
$$M_{U.L.} = 250 \ kN.m$$









$$\text{area } A_1 = 300\,a$$

$$\text{area } A_2 = \frac{1}{2} * 0.577\,a * a$$

$$A_2 = 0.288\,a^2$$

– Get a From

$$M_{U.L.} = \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\,(A_1)\left(d - \frac{a}{2}\right) + \frac{2}{3}\,\frac{F_{cu}}{\gamma_c}\,(2 * A_2)\left(d - \frac{2}{3}a\right)$$

$$\therefore\ 250 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(300\,a)\left(470 - \frac{a}{2}\right) + \frac{2}{3}\left(\frac{25}{1.5}\right)(2 * 0.288\,a^2)\left(470 - \frac{2}{3}a\right)$$

$a = 149.5$ mm $\qquad \therefore\ 0.1\,d < a < a_{max}$

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Get A_s From **Compression Force = Tension Force**

$$\boxed{C_{c1} + C_{c2} = T} \qquad \frac{2}{3}\frac{F_{cu}}{\gamma_c}(A_1) + \frac{2}{3}\frac{F_{cu}}{\gamma_c}(2 * A_2) = A_s * \frac{F_y}{\gamma_s}$$

$$\frac{2}{3}\left(\frac{25}{1.5}\right)(300 * 149.5) + \frac{2}{3}\left(\frac{25}{1.5}\right)(2 * 0.288 * 149.5^2) = A_s * \left(\frac{360}{1.15}\right)$$

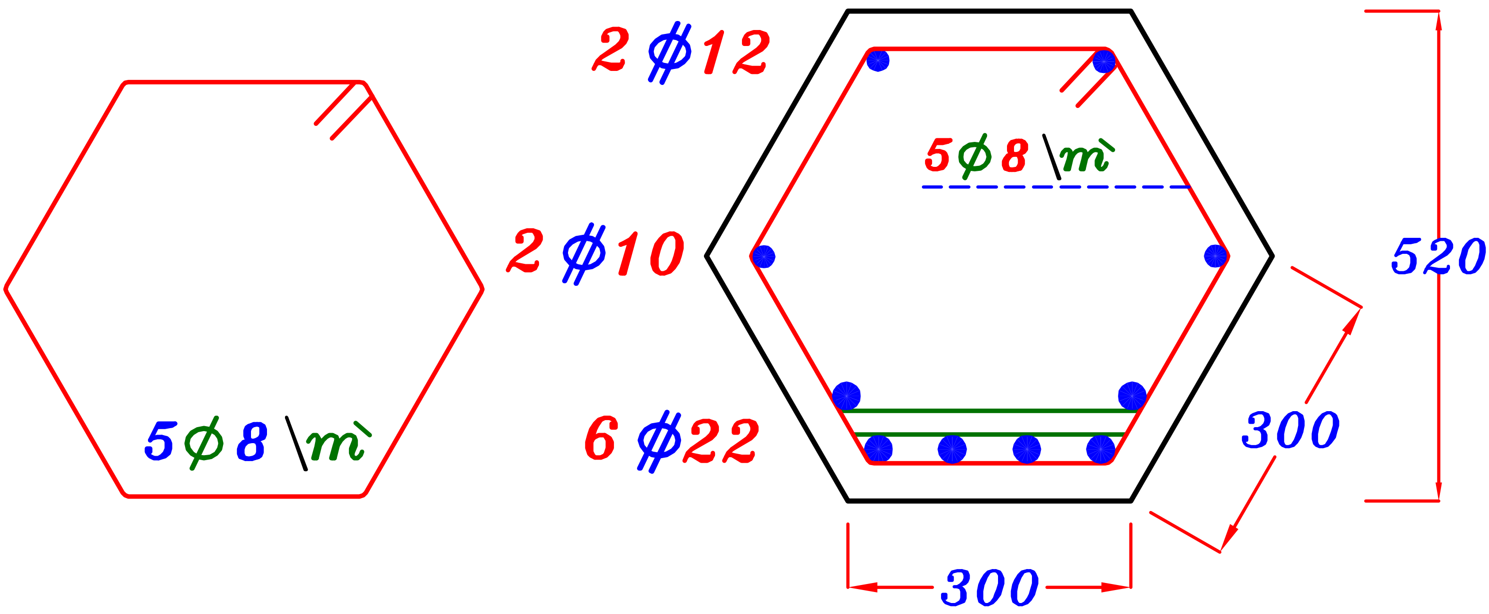
$$\therefore A_s = 2048.8 \quad mm^2 \qquad 6\ \phi\ 22$$

– Check $A_{s_{min.}} = \frac{1.1}{F_y}\, b\, d = \frac{1.1}{360}(300)(470) = 431\ mm^2$

$$\therefore A_{s_{min.}} < A_s = 2048.8 \quad mm^2$$

$$\therefore n = \frac{b - 25}{\phi + 25} = \frac{300 - 25}{22 + 25} = 5.85 = 5.0$$

Stirrup Hangers $= (0.1 \rightarrow 0.2)\, A_s = (0.1 \rightarrow 0.2)\, 2048.8$ $\quad 2\ \phi 12$



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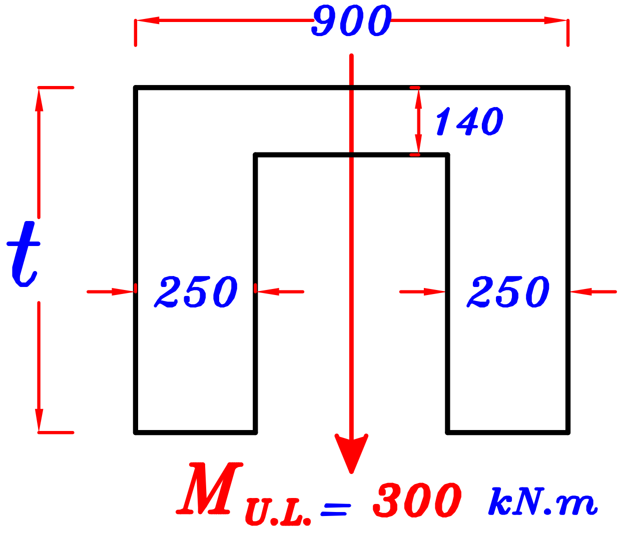
Example.

$F_{cu} = 25 \ N\backslash mm^2$, st. 360/520

$M_{U.L.} = 300 \ kN.m$

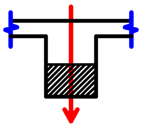


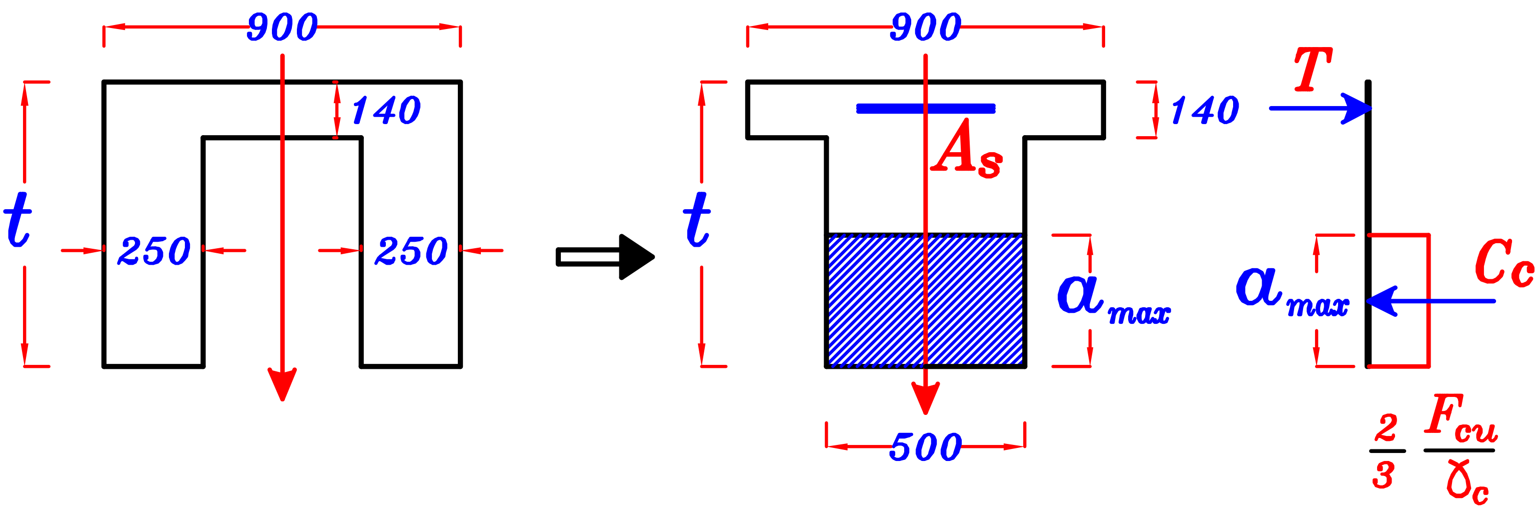
Req.

Using First Principles Design the Sec. For Bending

With min. Depth. & without A_{s}'

Solution.

R-Sec. 



To get $d_{min.}$ $\xrightarrow{Take}$ $a = a_{max.}$, $A_s = A_{s_{max.}}$

$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \gamma_s)}\right] * d = 0.35 \ d$$

$$\mu_{max.} = 5 * 10^{-4} * F_{cu} = 5 * 10^{-4} (25) = 0.0125$$

$$A_{s_{max.}} = \mu_{max.} \ b \ d = 0.0125 \, (500) \ d = 6.25 \ d$$

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From $M_{U.L.} = \frac{2}{3} \frac{F_{cu}}{\gamma_c} a_{max.} b \left(d_{min} - \frac{a_{max.}}{2}\right)$

$\therefore 300 * 10^6 = \frac{2}{3} \left(\frac{25}{1.5}\right) (0.35\, d_{min}) (500) \left(d_{min} - \frac{0.35\, d_{min}}{2}\right)$

$\therefore d_{min.} = 432.45\ mm$ $\xrightarrow{Take}$ $\boxed{d = 450\ mm}$, $\boxed{t = 500\ mm}$

- Get A_s From

$A_s = A_{s_{max.}} = 6.25\ d = 6.25\ (432.45) = 2702.8\ mm^2$

$14 \phi 16$

$\therefore n = \frac{b - 25}{\phi + 25} = \frac{900 - 25}{16 + 25} = 21.3 = 21.0$

Stirrup Hangers $= (0.1 \rightarrow 0.2)\, A_s = (0.1 \rightarrow 0.2)\ 2702.8$ $4 \phi 12$

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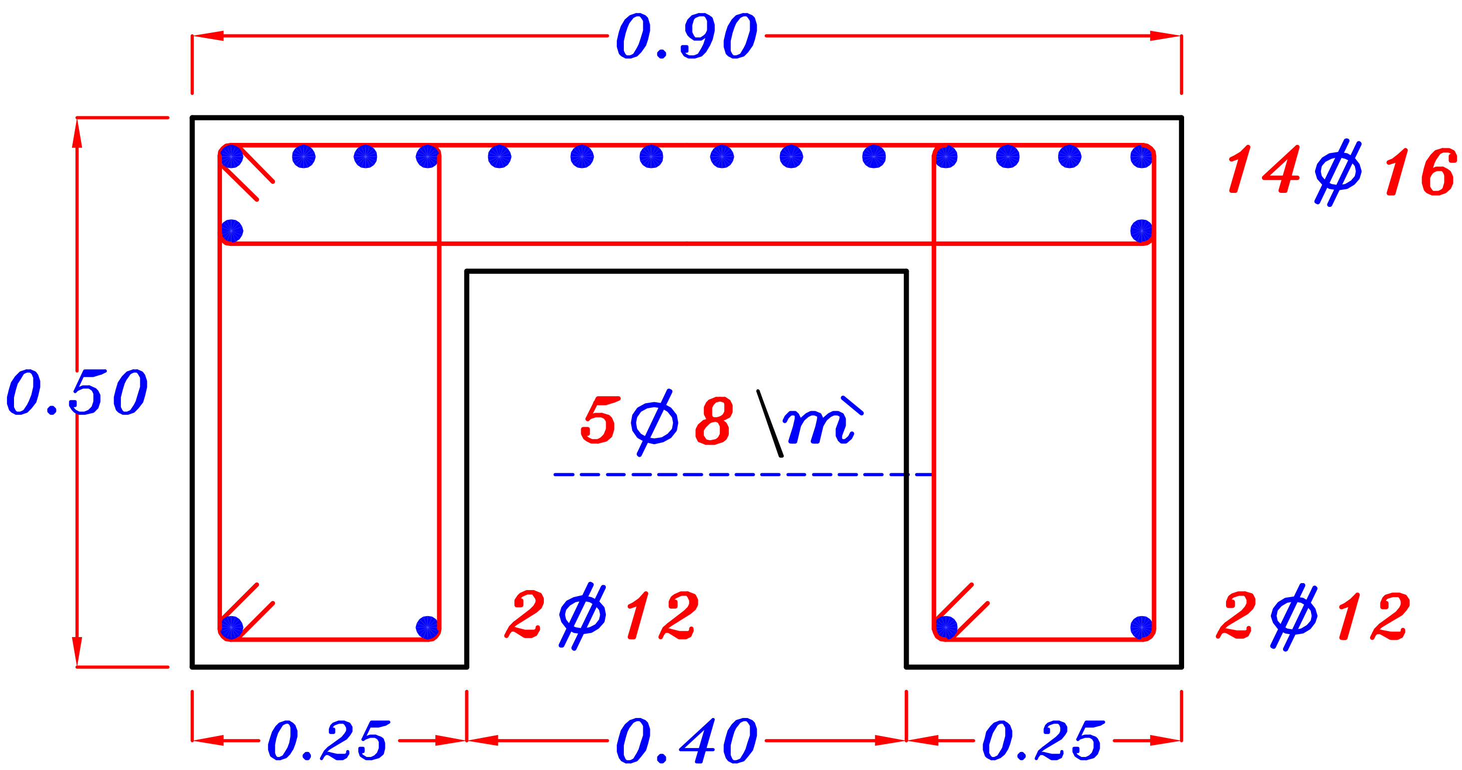

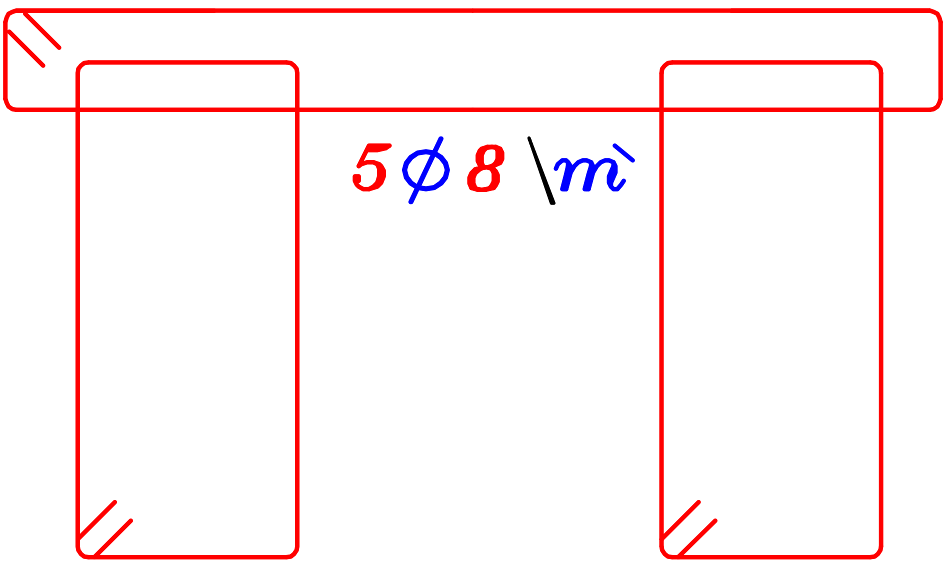

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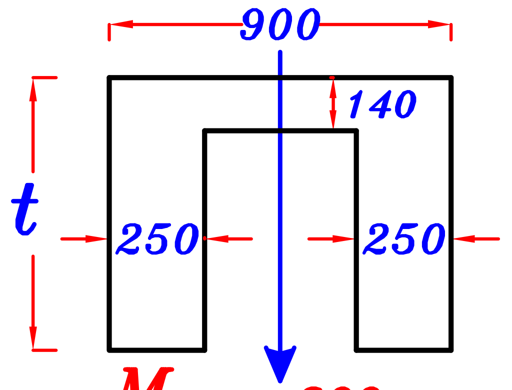
Example.



$M_{U.L.} = 300$ kN.m

$F_{cu} = 25$ N\mm^2 , st. 360/520

$M_{U.L.} = 300$ kN.m

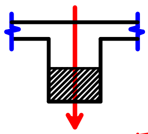
Req.

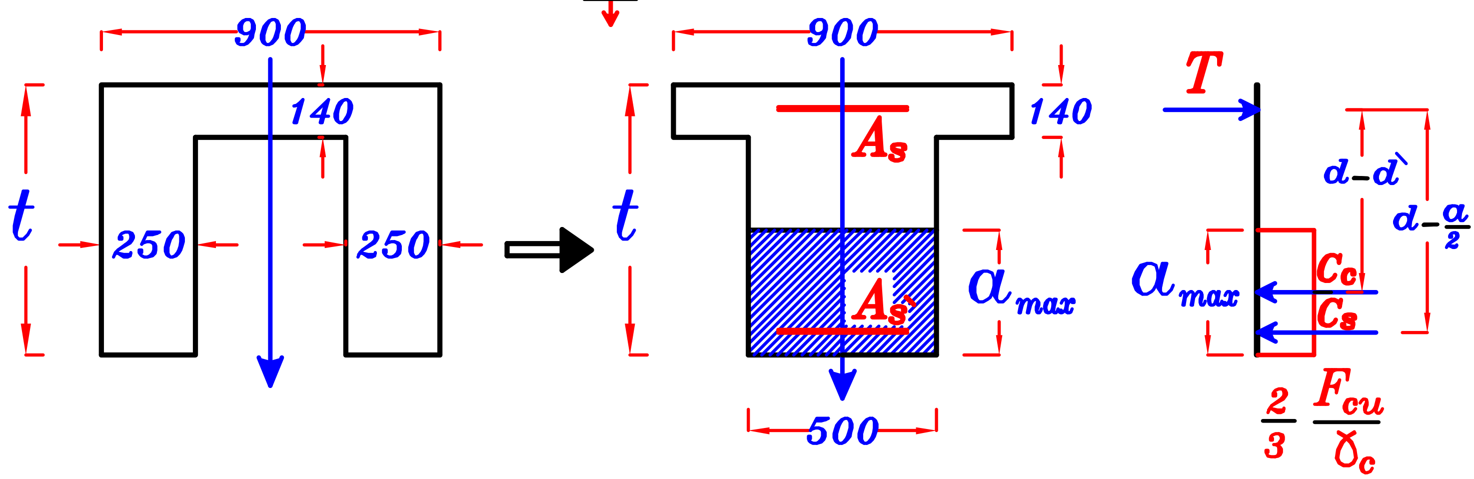
Using First Principles Design the Sec. For Bending

With min. Depth. & with $A_{s`}$

Solution.

R-Sec.





To get $d_{min.}$ $\xrightarrow{when}$ $a = a_{max.}$, $A_s = A_{s_{max.}} + A_{s`}$ , $A_{s`} = A_{s`_{max.}}$

يجب عمل هذا الاثبات أولا

$$A_{s`_{max.}} = 0.4\, A_s = 0.4\,(A_{s_{max.}} + A_{s`_{max.}})$$

$$\therefore A_{s`_{max.}} = 0.4\,(\mu_{max.}\, b\, d + A_{s`_{max.}})$$

$$\therefore A_{s`_{max.}} = 0.4\,\mu_{max.}\, b\, d + 0.4\, A_{s`_{max.}}$$

$$\therefore 0.6\, A_{s`_{max.}} = 0.4\,\mu_{max.}\, b\, d$$

$$\therefore \boxed{A_{s`_{max.}} = \frac{2}{3}\,\mu_{max.}\, b\, d}$$

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$$a_{max} = 0.8\left(\frac{2}{3}\right)\left[\frac{600}{600 + (F_y \backslash \gamma_s)}\right] * d = 0.35\ d$$

$$\mu_{max.} = 5 * 10^{-4} * F_{cu} = 5 * 10^{-4}\,(25) = 0.0125$$

$$A_{s_{max.}} = \mu_{max.}\ b\ d = 0.0125\ (500)\ d = 6.25\ d$$

$$A_{s`_{max.}} = 0.4\ A_s = \frac{2}{3}\ \mu_{max.}\ b\ d = \frac{2}{3}\ (0.0125)\ (500)\ d = 4.16\ d$$

From $$M_{U.L.} = \frac{2}{3}\ \frac{F_{cu}}{\gamma_c}\ a_{max.}\ b\left(d_{min} - \frac{a_{max.}}{2}\right) + A_{s`_{max.}}\ \frac{F_y}{\gamma_s}\left(d_{min} - d`\right)$$

$$\therefore 300 * 10^6 = \frac{2}{3}\left(\frac{25}{1.5}\right)(0.35\ d_{min})\ (500)\left(d_{min} - \frac{0.35\ d_{min}}{2}\right) + (4.16\ d_{min})\left(\frac{360}{1.15}\right)(d_{min} - 50)$$

$\therefore d = 332.6$ mm $\xrightarrow{\text{Take}}$ $\boxed{d = 350mm}$, $\boxed{t = 400\ mm}$

- Get A_s From

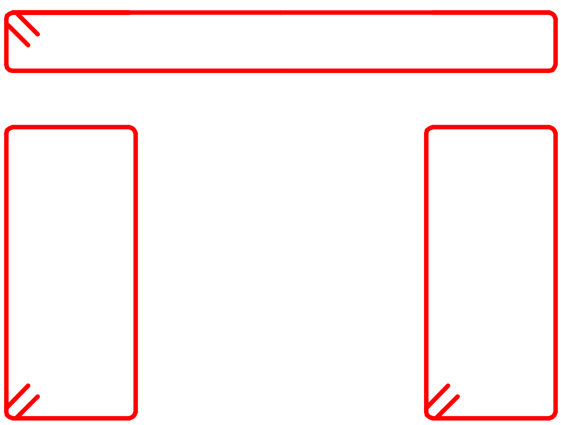
$$A_{s_{max.}} = 6.25\ d = 6.25\ (332.6) = 2078.7\ mm^2$$

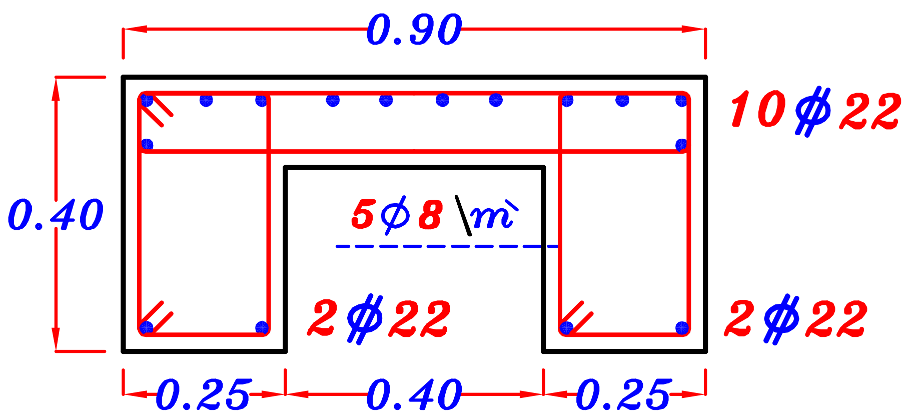
$$A_{s`_{max.}} = 4.16\ d = 4.16\ (332.6) = 1383.6\ mm^2$$ 4 φ 22

$$A_s = A_{s_{max.}} + A_{s`_{max.}} = 2078.7 + 1383.6 = 3462.3\ mm^2$$ 10 φ 22

$$\therefore\ n = \frac{b - 25}{\phi + 25} = \frac{900 - 25}{22 + 25} = 18.6 = 18.0$$

5φ8 \m`





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